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Public Health Service
Washington, D. C.

September 1963

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VOLUME IV, NUMBER 7
July 1963

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

International Numerical Prefixes to be Used in Reporting Data

Effective with this issue, the reporting units used in Radiological Health Data will adhere to the numerical multiple and submultiple prefixes previously established by the International Committee on Weights and Measures and recently adopted by the National Bureau of Standards These prefixes in combination with the curie unit (see inside back cover) eliminate the need for compound prefixes which appear in millimicrocurie (mμc) and micromicrocurie (μμc).

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Early indications of possible fission product activity fluctuations in other phases of the environment are being secured through the continuous surveillance of gross beta activity in air and precipitation. The information obtained through this form of surveillance does not by itself permit evaluation of biological effects due to fallout, but it does form the basis of an alerting system and can be used as a rough guide for determining when and where more extensive monitoring of radioactivity in food, milk, and water is desirable.

In this section, March 1963 gross beta concentrations are presented in reports from the Radiation Surveillance Network, the National Air Sampling Network, the Canadian Radioactive Fallout Study Program, and the Mexican Radioactive Fallout Program. Network intercalibration factors, determined by Lockhart and Patterson (*1*), were used in constructing the isogram map (figure 5), which presents data on Canadian and U. S. gross beta radioactivity in air for March. To adjust the data from the two networks to a common baseline, the U. S. data were multiplied by a factor of 1.54, the U. S.-Canadian intercalibration factor suggested by the NRL study.

REFERENCE

(*1*) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Washington, D. C. (November 13, 1962); abstracted in December 1962 *Radiological Health Data.*

RADIATION SURVEILLANCE NETWORK
March 1963

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) comprises 72 sampling stations distributed throughout the United States (see figure 1). Most of these stations are manned by State health department personnel.

Air

Daily 24-hour air samples are collected on a 4-inch diameter, carbon-loaded cellulose dust filter in a high-volume air sampler. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}-Y^{90} known activity source. This determination is usually made about 5 hours after the end of collection to eliminate interference from naturally occurring radon daughters. The network's station operators contribute to a daily national report of radioactivity in air by telephoning their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined meas-

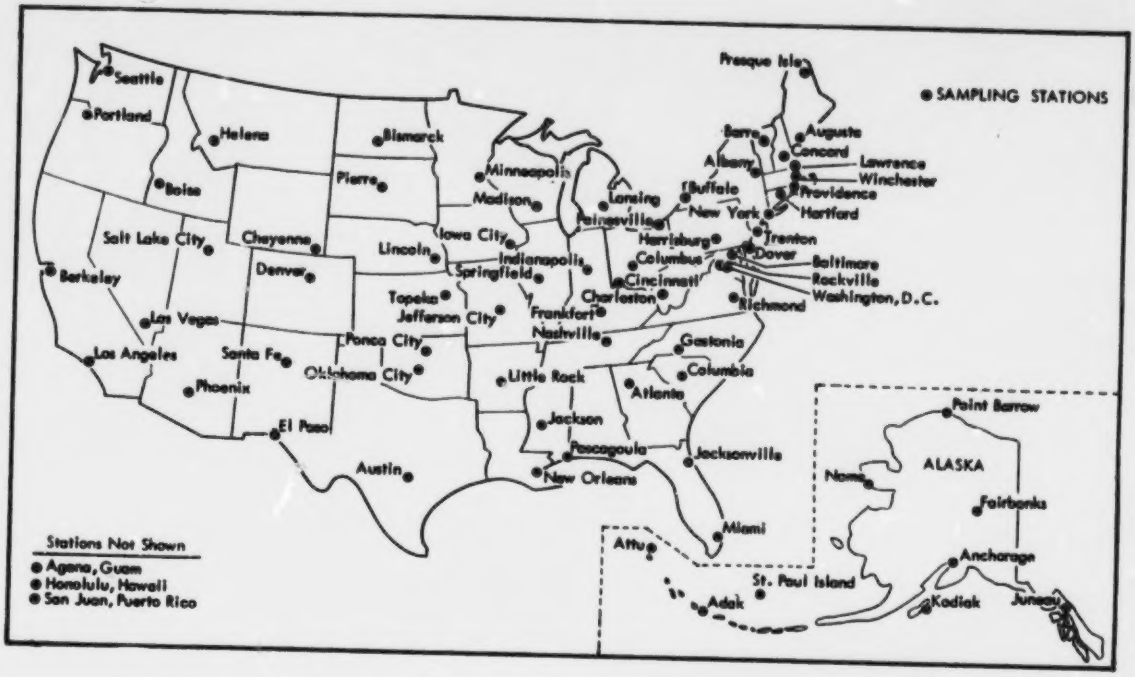
● SAMPLING STATIONS
Seattle
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Painesville
Buffalo
Presque Isle
Barre
Augusta
Albany
Concord
Lawrence
Winchester
Providence
Hartford
New York
Trenton
Dover
Harrisburg
Baltimore
Rockville
Washington, D.C.
Columbus
Cincinnati
Charleston
Richmond
Salt Lake City
Cheyenne
Denver
Lincoln
Iowa City
Indianapolis
Springfield
Topeka
Jefferson City
Frankfort
Nashville
Berkeley
Las Vegas
Los Angeles
Santa Fe
Phoenix
Ponca City
Oklahoma City
Little Rock
Gastonia
Columbia
Atlanta
El Paso
Austin
Jackson
Pascagoula
New Orleans
Jacksonville
Miami
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Adak
St. Paul Island
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, MARCH 1963

urement using a thin-window, gas-flow proportional counter. Each filter is counted at least 3 days after the end of the sampling period and re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally occurring radon and thoron daughters. From the two counts, which are separated by a 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula: $AT^{1.2} = \text{constant}$ (*1*).* The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*2*).

The average fission-product beta concentrations in surface air during March 1963, as determined by laboratory analysis and extrapolated to the time of collection, are given in table 1.

In order to compare U. S. air data and the gross beta concentrations reported by Canada, an adjustment is required. The relationshi given by Lockhart and Patterson[1] is

$$\frac{\text{PHS}}{\text{Canada}} = 0.65 \pm 0.048 \text{ (one standard deviation)}$$

which may be written:

$$1.54 \times \text{PHS} \pm 7.4 \text{ percent} = \text{Canada}$$

It was considered more appropriate to adjust the RSN values upward to correspond with Canada's than to adjust the Canadian data downward. This was done in consideration of the higher filter efficiency and lower self-absorption of the Canadian system compared with that of the RSN.[1]

The Canadian air data and the adjusted RSN data have been combined in the map (figure 5) which includes most of the North American continent.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis

---

* In this expression, A is the activity and T is the time after fission product formation.

[1] See reference (*1*) on page 331.

TABLE 1.—GROSS BETA ACTIVITY OF PARTICULATES IN AIR, RSN, MARCH 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average [a]
Alaska:	Adak	31	7.8	0.23	3.8
	Anchorage	29	9.1	0.19	4.7
	Attu	31	9.6	<0.10	4.9
	Fairbanks	29	7.0	1.0	3.8
	Juneau	28	8.9	0.28	2.9
	Kodiak	31	9.2	0.14	3.4
	Nome	18	3.7	<0.10	1.9
	Point Barrow	24	5.8	0.29	2.8
	St. Paul Island	31	8.0	0.26	3.5
Ariz:	Phoenix	29	15	3.8	9.7
Ark:	Little Rock	29	17	2.1	7.2
Calif:	Berkeley	28	11	1.8	5.0
	Los Angeles	21	13	3.4	6.9
Colo:	Denver	29	24	2.1	9.6
Conn:	Hartford	31	12	0.87	4.7
Del:	Dover	20	12	2.7	7.3
D.C:	Washington	31	14	1.1	5.4
Fla:	Jacksonville	31	11	2.8	5.6
	Miami	29	13	2.6	6.6
Ga:	Atlanta	31	11	1.6	5.3
Guam:	Agana	28	12	0.57	3.4
Hawaii:	Honolulu	31	6.4	1.1	2.9
Idaho:	Boise	31	12	2.5	5.8
Ill:	Springfield	30	8.9	1.3	4.5
Ind:	Indianapolis	30	10	1.0	5.5
Iowa:	Iowa City	29	6.6	1.1	3.5
Kans:	Topeka	31	9.6	0.69	4.1
Ky:	Frankfort	28	10	1.9	5.9
La:	New Orleans	31	11	1.3	5.1
Maine:	Augusta	31	14	2.8	7.4
	Presque Isle	20	8.6	3.6	6.1
Md:	Baltimore	20	9.6	1.0	5.7
	Rockville	17	9.2	0.77	5.4
Mass:	Lawrence	28	11	0.83	4.6
	Winchester	29	23	1.8	8.5
Mich:	Lansing	31	13	3.5	7.0
Minn:	Minneapolis	31	8.8	1.9	4.2
Miss:	Jackson	29	11	0.23	5.6
	Pascagoula	20	13	1.6	4.7
Mo:	Jefferson City	31	8.6	0.97	4.3
Mont:	Helena	31	11	1.5	5.3
Nebr:	Lincoln	17	7.7	1.1	3.6
Nev:	Las Vegas	25	23	3.6	11
N.H:	Concord	21	13	1.7	7.1
N.J:	Trenton	31	11	1.5	5.1
N. Mex:	Santa Fe	31	15	2.0	8.2
N.Y:	Albany	31	9.4	0.96	5.7
	Buffalo	30	8.6	1.6	5.4
	New York	13	9.5	1.4	3.8
N.C:	Gastonia	30	15	2.1	8.5
N. Dak:	Bismarck	31	11	1.8	4.1
Ohio:	Cincinnati	21	8.2	1.5	4.5
	Columbus	30	11	2.0	6.0
	Painesville	24	14	2.8	6.5
Okla:	Oklahoma City	31	12	0.56	4.8
	Ponca City	29	7.8	0.58	2.9
Ore:	Portland	30	16	1.2	6.8
Pa:	Harrisburg	16	9.0	1.8	5.2
P.R:	San Juan	31	6.5	2.4	4.1
R.I:	Providence	31	15	1.1	5.6
S.C:	Columbia	27	9.0	3.0	5.5
S. Dak:	Pierre	31	11	1.0	4.1
Tenn:	Nashville	29	14	3.1	7.5
Tex:	Austin	31	15	2.4	6.9
	El Paso	31	21	3.8	8.4
Utah:	Salt Lake City	31	22	1.9	7.6
Vt:	Barre	31	16	0.76	7.3
Va:	Richmond	31	6.7	1.6	4.3
Wash:	Seattle	31	7.7	0.84	2.7
W. Va:	Charleston	31	9.8	2.7	5.9
Wisc:	Madison	28	12	2.1	5.6
Wyo:	Cheyenne	31	23	1.5	7.5
Network average					5.5

[a] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, MARCH 1963

Station location		Average concentration (pc/liter)	Total deposition [a] (nc/m²)
Alaska:			
	Anchorage	2,800	9.8
	Fairbanks	1,000	57
	Juneau	b	b
Ariz:	Phoenix	b	b
Ark:	Little Rock	900	140
Calif:	Berkeley	910	78
	Los Angeles	1,300	130
Colo:	Denver	1,800	6.1
Conn:	Hartford	2,300	200
D.C:	Washington	1,300	170
Fla:	Jacksonville	830	55
	Miami	1,300	14
Ga.	Atlanta	<400	<13
Hawaii:	Honolulu	b	b
Idaho:	Boise	4,300	16
Ill:	Springfield	950	90
Ind:	Indianapolis	1,900	440
Iowa:	Iowa City	2,100	98
Kans:	Topeka	1,700	120
Ky:	Frankfort	1,400	150
La:	New Orleans	1,100	22
Maine:	Augusta	1,000	91
Md.	Baltimore	2,200	66
Mass:	Lawrence	1,000	95
	Winchester	1,700	160
Mich:	Lansing	b	b
Minn:	Minneapolis	2,400	84
Miss:	Jackson	1,200	46
Mo:	Jefferson City	1,300	140
Mont:	Helena	3,800	7.6
Nebr:	Lincoln	2,300	99
Nev:	Las Vegas	b	b
N.J:	Trenton	2,400	60
N. Mex:	Santa Fe	4,200	60
N.Y:	Albany	860	24
	Buffalo	b	33
N.C:	Gastonia	710	110
N. Dak:	Bismarck	2,300	3.9
Ohio:	Columbus	1,800	280
	Painesville	2,500	190
Okla:	Oklahoma City	1,600	30
	Ponca City	1,700	100
Ore:	Portland	1,400	110
Pa:	Harrisburg	1,300	36
P.R:	San Juan	1,200	110
R.I:	Providence	1,600	140
S.C:	Columbia	910	78
S. Dak:	Pierre	1,600	18
Tenn:	Nashville	1,700	200
Tex:	Austin	5,800	7.2
	El Paso	b	b
Utah:	Salt Lake City	1,900	120
Vt:	Barre	1,400	97
Va:	Richmond	1,000	110
Wash:	Seattle	1,200	110
W. Va:	Charleston	2,300	280
Wisc:	Madison	2,400	140
Wyo:	Cheyenne	1,800	24

[a] Precipitation (mm) $= \frac{\text{nc/m}^2}{\text{pc/liter}} \times 1000$

[b] No evaporated sample received.

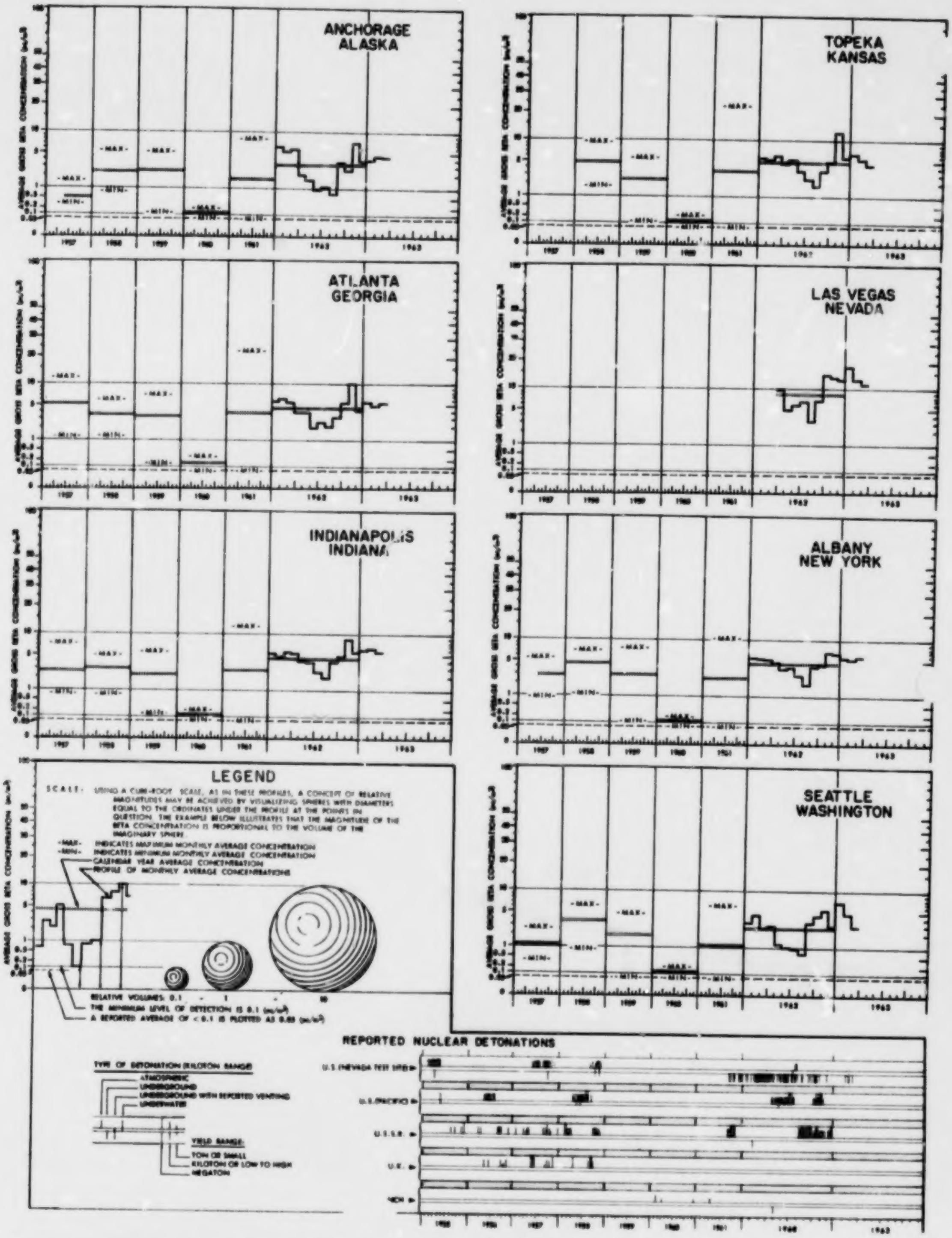

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1957-MARCH 1963

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using funnels with collection areas of 0.4 square meters. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples, including extrapolation to the time of collection. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made. March 1963 averages of gross beta activity in precipitation, expressed in picocuries per liter (pc/liter) and nanocuries per square meter (nc/m^2), are presented in table 2.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in *RHD*, July 1961. The profiles of 7 stations, updated through March 1963, are shown in figure 2.

REFERENCES

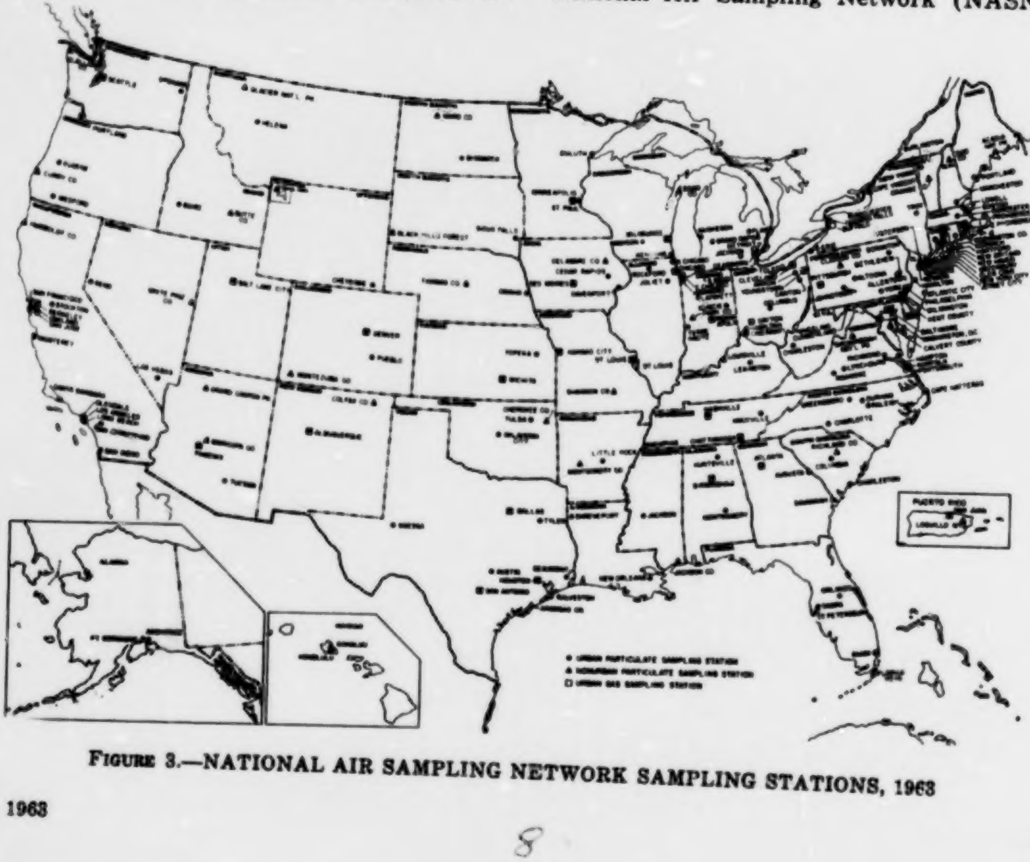
(*1*) Way, K., and E. P. Wigner: The Rate of Decay of Fission Products, *Physics Review*, *37*:1318-30 (June 1948).

(*2*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington 25, D. C. (Distribution by official request).

NATIONAL AIR SAMPLING NETWORK
First Quarter 1963

Division of Air Pollution, Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in



● URBAN PARTICULATE SAMPLING STATION
▲ NONURBAN PARTICULATE SAMPLING STATION
☐ URBAN GAS SAMPLING STATION

FIGURE 3.—NATIONAL AIR SAMPLING NETWORK SAMPLING STATIONS, 1963

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, FIRST QUARTER 1963

[Concentrations in pc/m³]

Station location		Number of samples	Minimum	Maximum	Average
Ala:	Birmingham	6	0.8	15.6	8.9
	Huntsville	6	1.0	16.6	8.1
	Montgomery	6	1.9	14.3	8.9
Alaska:	Anchorage	6	0.8	16.6	7.2
	Pt. Woronzof*	7	1.4	16.5	7.8
Ariz:	Grand Canyon Pk.*	7	5.7	47.2	18.7
	Maricopa Co.*	6	18.6	26.5	19.8
	Phoenix	6	11.3	26.7	18.3
	Tucson	6	7.2	23.4	15.3
Ark:	Little Rock	5	6.2	13.6	10.8
	Montgomery Co.*	5	4.7	15.3	8.9
Calif:	Berkeley	3	2.8	24.4	11.2
	Glendale	5	10.1	17.6	13.1
	Humboldt Co.*	7	2.7	24.6	6.7
	Long Beach	6	7.1	24.6	15.7
	Los Angeles	6	7.3	30.0	12.9
	Monterey	3	4.4	5.1	4.7
	Oakland	6	3.7	27.5	9.9
	San Bernardino	3	12.0	25.2	17.6
	San Diego	6	5.8	29.7	14.5
	San Francisco	6	4.2	25.6	9.5
	San Jose	6	4.3	29.6	10.1
	Santa Barbara	5	3.1	31.4	14.3
	Stockton	6	3.6	11.0	6.2
Colo:	Denver	5	6.4	16.6	9.2
	Montezuma Co.*	7	3.8	27.6	15.4
	Pueblo	6	8.0	22.4	13.2
Conn:	Hartford	3	2.8	7.1	5.3
	New Britain	5	3.6	11.0	7.6
	New Haven	6	3.8	11.7	7.9
	Norwich	6	3.0	14.2	8.5
	Waterbury	6	3.2	8.1	5.6
Del:	Kent Co.*	4	1.7	7.5	5.0
	Wilmington	5	2.6	9.7	6.8
D. C:	Washington	6	2.4	11.2	6.6
Fla:	Florida Keys*	6	5.3	16.3	11.2
	Miami	6	4.7	17.1	11.4
	Orlando	5	5.1	18.7	10.6
	St. Petersburg	6	4.2	12.5	7.9
	Tampa	5	4.8	12.1	8.0
Ga:	Atlanta	6	0.5	16.0	7.9
	Augusta	6	4.2	15.1	9.3
	Savannah	6	4.0	12.1	8.2
Hawaii:	Honolulu	6	3.3	12.4	6.9
	Kahaluu*	7	4.0	12.8	6.8
Idaho:	Boise	6	6.5	26.5	15.1
	Butte Co.*	7	7.2	22.5	13.1
Ill:	Chicago	4	2.6	6.3	5.7
	East St. Louis	6	6.4	11.5	8.9
	Joliet	6	4.2	9.6	7.6
	North Chicago	4	5.0	12.4	9.2
	Rockford	6	3.6	9.5	7.6
Ind:	East Chicago	4	3.3	16.8	8.4
	Hammond	6	4.9	9.1	7.3
	Indianapolis	4	3.2	12.2	7.1
	Muncie	6	4.4	9.7	7.8
	Parke Co.*	7	7.5	16.5	11.3
	South Bend	6	6.1	16.5	8.9
	Terre Haute	4	5.9	10.9	8.3
Iowa:	Cedar Rapids	6	4.2	12.8	8.3
	Davenport	6	4.9	15.5	9.6
	Delaware Co.*	7	2.6	9.2	6.7
	Des Moines	6	2.2	8.7	4.6
Kans:	Topeka	6	3.2	10.3	7.5
	Wichita	6	3.2	17.0	9.9
Ky:	Lexington	6	2.8	12.4	9.0
	Louisville	5	4.7	10.2	7.4
La:	New Orleans	6	1.4	14.7	8.1
	Shreveport	6	5.3	17.0	8.7
Maine:	Acadia Nat. Park*	6	2.2	9.4	6.2
	Portland	6	3.3	11.8	8.5
Md:	Baltimore	6	1.9	8.6	4.9
	Calvert Co.*	8	2.5	17.0	8.1
	Cumberland	6	5.5	8.1	6.9
Mass:	Boston	4	2.8	7.5	5.6
	Lowell	6	3.9	16.7	10.8
	Worcester	6	2.4	10.5	7.4
Mich:	Dearborn	6	5.4	10.8	8.1
	Detroit	6	4.0	8.9	5.8
	Flint	4	4.5	6.0	4.9
	Grand Rapids	4	4.3	7.8	5.6
	Jackson	6	6.5	17.3	9.8
	Muskegon	5	4.8	10.5	7.2
Minn:	Duluth	6	3.2	8.3	6.0
	Minneapolis	6	1.5	8.2	5.9
	St. Paul	6	2.8	9.3	6.4
Miss:	Jackson	5	2.5	18.4	10.8
	Jackson Co.*	4	1.0	17.9	9.4
Mo:	Kansas City	6	8.7	17.2	9.5
	Shannon Co.*	6	5.5	19.6	12.0
	St. Louis	6	4.9	12.4	9.0
Mont:	Glacier Nat. Pk.*	3	2.5	9.5	5.5
	Helena	6	4.6	22.0	10.1
Nebr:	Omaha	6	1.7	13.7	8.5
	Thomas Co.*	6	5.8	20.4	11.3
Nev:	Las Vegas	6	18.4	27.5	19.2
	Reno	5	5.3	18.6	11.4
	White Pine Co.*	7	7.0	36.5	16.1
N.H:	Coos Co.*	4	5.9	15.3	9.0
N.J:	Atlantic City	5	5.5	11.0	7.6
	Bayonne	6	2.7	9.8	5.6
	Hamilton	5	4.0	9.9	6.7
	Jersey City	4	2.5	11.4	7.6
	Newark	6	2.2	10.4	5.9
	Paterson	6	2.1	9.3	5.8
N.M:	Albuquerque	6	10.8	25.6	15.6
	Colfax Co.*	7	7.7	38.4	21.7
N.Y:	Cape Vincent	6	5.3	20.3	9.2
	Glen Cove*	2	5.1	5.9	5.5
	Massena	6	3.2	8.7	6.4
	New York City	6	6.9	13.0	9.6
	Niagara Falls	5	5.7	11.0	8.3
	Rochester	5	3.8	8.4	6.6
	Troy	5	3.9	14.4	7.3
N.C:	Cape Hatteras	6	4.4	14.8	8.9
	Charlotte	6	5.3	17.9	9.9
	Durham	6	2.1	16.2	8.2
	Greensboro	6	0.6	17.4	9.3
	Raleigh	6	1.7	9.4	6.0
N. Dak:	Bismarck	6	4.8	11.5	7.7
	Ward Co.*	6	2.7	15.4	7.8
Ohio:	Akron	6	4.7	9.0	6.5
	Canton	6	4.6	8.7	6.9
	Cincinnati	6	5.1	9.7	7.2
	Cleveland	6	4.7	16.0	8.6
	Columbus	6	5.1	10.5	7.1
	Dayton	6	5.2	8.8	7.2
	Hamilton	6	5.0	10.0	7.9
	Toledo	6	5.3	10.9	7.6
	Youngstown	6	4.8	10.6	7.3
Okla:	Cherokee Co.*	7	4.6	16.2	9.3
	Oklahoma City	4	3.6	22.5	10.7
	Tulsa	5	5.7	18.4	12.8
Ore:	Curry Co.*	5	2.6	10.8	6.2
	Eugene	5	2.4	24.1	8.9
	Medford	5	2.0	6.9	4.7
	Portland	5	2.8	22.0	8.8
Pa:	Allentown	7	2.4	10.0	6.1
	Altoona	2	4.8	10.8	7
	Bethelehem	6	1.3	13.4	[illegible]
	Clarion Co.*	5	3.9	8.0	[illegible]
	Erie	6	4.9	10.9	8.3
	Johnstown	5	2.7	10.5	6.6
	Philadelphia	5	1.5	12.8	6.7
	Pittsburgh	6	5.0	9.5	7.1
	Scranton	6	3.3	9.2	6.0
	York	6	2.2	10.4	5.9
P.R:	Loquillo Mountains*	3	1.8	4.7	3.7
	San Juan	5	0.6	7.6	4.9
R.I:	East Providence	6	3.3	11.4	7.4
	Providence	6	3.0	9.4	6.8
	Washington Co.*	7	6.5	11.7	8.2
S.C:	Charleston	6	4.1	23.8	10.6
	Columbia	6	1.3	13.0	7.8
	Richland Co.*	7	7.8	25.6	13.9
S. Dak:	Black Hills Forest*	7	7.7	25.1	13.0
	Sioux Falls	5	3.3	10.5	7.4
Tenn:	Chattanooga	6	8.0	15.2	11.9
	Knoxville	5	2.9	14.1	7.5
	Memphis	6	5.2	17.5	11.6
	Nashville	6	4.3	15.4	10
Texas:	Aransas	6	3.9	17.5	8.8
	Austin	6	6.2	17.6	11.7
	Beaumont	3	6.9	11.7	9.2
	Dallas	5	5.2	11.7	8.0
	Galveston	6	5.5	13.6	8.9
	Houston	5	3.1	14.7	8.1
	Odessa	6	9.4	19.0	13.2
	San Antonio	6	4.4	21.1	11.3
	Tyler	6	3.9	14.2	9.8
Utah:	Salt Lake City	6	5.0	19.8	13.8
Vt:	Burlington	6	3.3	13.6	8.6
	Orange Co.*	7	1.9	16.7	8.6
Va:	Hampton	6	2.8	8.0	5.7
	Lynchburg	6	1.6	14.4	7.9
	Norfolk	6	3.8	15.3	7.6
	Portsmouth	6	3.1	18.1	8.4
	Richmond	6	4.4	13.1	8.4
	Roanoke	4	8.8	16.8	11.5
	Shenandoah Nat. Pk.*	7	4.6	20.3	9.3
Wash:	Clallam Co.*	3	2.5	2.6	2.6
	Seattle	6	2.0	23.0	6.5
	Spokane	5	2.3	17.2	9.0
W. Va:	Charleston	6	6.1	11.4	9.0
	Wheeling	6	4.9	13.7	7.9
Wisc:	Door Co.*	6	2.8	10.7	7.2
	Kenosha	6	4.6	9.4	7.8
	Madison	6	4.1	10.2	7.5
	Milwaukee	6	3.5	9.7	6
Wyo:	Cheyenne	6	9.3	20.8	1
	Yellowstone Pk.*	7	4.6	19.4	1

*Nonurban Station.

1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. These analyses aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

Gross Beta Activity in Air

NASN stations (see figure 3) are manned by cooperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, there are 240 sampling stations in all in the NASN network, of which 175 are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are then sent for analysis to the Network laboratory in Cincinnati, Ohio. First quarter 1963 data appear in table 3.

Gross Beta Activity in Precipitation

The present reporting of gross beta activity in precipitation originated in 1959 when a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio, and the National Air Sampling Network. Monthly composite samples of precipitation are collected at 29 stations, which are located at Weather Bureau offices or airports. They are then forwarded to the Network laboratory for analysis.

The laboratory analyzes these samples for total solids and for a large number of metals and nonmetals. In addition, each sample is analyzed for fission product gross beta radioactivity if a sufficient volume of precipitation remains after chemical analyses have been made. Precipitation data for the first quarter of 1963 are shown in table 4.

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, NASN, FIRST QUARTER 1963

Station		January		February		March	
		pc/liter	nc/m ^{2}	pc/liter	nc/m ^{2}	pc/liter	nc/m ^{2}
Alabama:	Montgomery	472	79.4	1080	73.1	1220	51.7
California:	Santa Maria			350	22.1		
Colorado:	Grand Junction	525	23.1				
Florida:	Tampa			270	15.9		
Louisiana:	Lake Charles	554	56.5	800	84.0		
Maine:	Caribou	865	54.5	550	44.3	890	55.4
Massachusetts:	Nantucket	1852	169.6	1030	113.5	1020	119.4
Michigan	Sault Ste. Marie					2070	107.9
Missouri:	Columbia					1040	85.2
New York:	Albany	1920	105.8			3140	153.0
North Carolina:	Cape Hatteras	1239	120.8	920	158.8	1130	44.8
Ohio:	Cincinnati (Airport)	1583	60.5			1420	273.4
	Cincinnati (Gest St.)	2612	115.2			2360	440.5
Pennsylvania:	Philadelphia	2487	134.6	1010	53.3	1190	117.4
South Carolina:	Charleston	862	58.2	470	65.9		
	Greenville	739	72.1	1380	109.1	410	99.2
Tennessee:	Nashville			1200	65.6	700	126.9
Virginia	Sterling			1260	54.1	980	105.6
Washington:	Tatoosh			1500	170.6	1360	111.7

CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM, March 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four RFSP collection stations are located at airports (see figure 4) where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

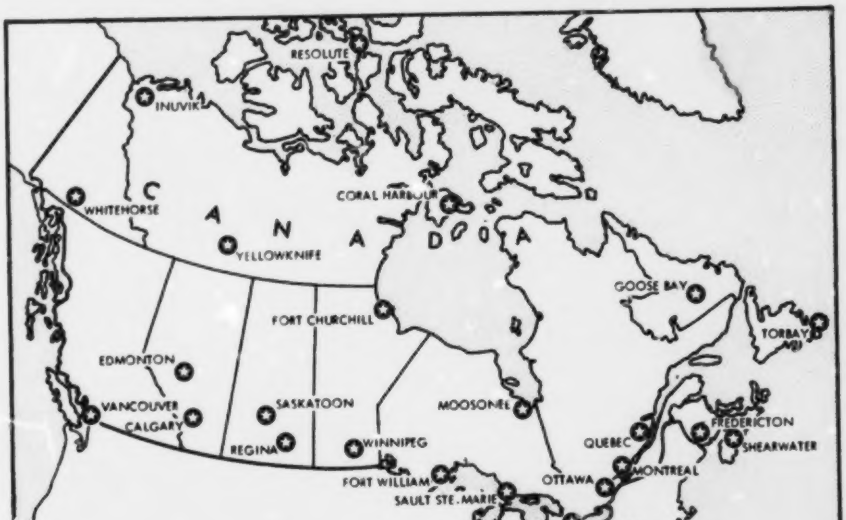
Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is removed from each filter and counted with a thin-end-window Geiger flow counter system, calibrated with a

TABLE 5.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, RFSP, MARCH 1963

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	31	22.0	3.5	9.0
Coral Harbour	27	13.9	2.9	8.1
Edmonton	31	13.9	3.0	6.4
Ft. Churchill	30	10.4	4.5	7.0
Ft. William	31	17.2	4.6	10.4
Fredericton	31	21.0	3.7	12.6
Goose Bay	31	12.1	0.4	8.4
Inuvik	31	17.7	6.2	10.7
Montreal	30	18.8	4.4	11.6
Moosonee	30	19.0	7.5	12.2
Ottawa	30	19.0	5.0	11.8
Quebec City	30	26.0	4.7	13.2
Regina	31	19.0	2.7	8.4
Resolute	13	10.0	4.8	7.9
Saskatoon	31	16.8	3.3	8.2
Sault St. Marie	30	16.9	7.5	10.8
Shearwater	30	24.0	2.1	12.2
Torbay	29	19.0	1.6	8.1
Toronto	31	17.0	1.1	9.9
Vancouver	31	15.6	1.7	6.5
Whitehorse	31	19.4	0.8	9.4
Windsor	30	16.2	3.9	10.5
Winnipeg	31	12.7	3.9	8.6
Yellowknife	31	22.2	5.9	[illegible]
Average				9.[illegible]


RESOLUTE
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WHITEHORSE
YELLOWKNIFE
CORAL HARBOUR
GOOSE BAY
FORT CHURCHILL
TORBAY
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
SHEARWATER
MONTREAL
OTTAWA
FORT WILLIAM
SAULT STE. MARIE
TORONTO
WINDSOR

FIGURE 4.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

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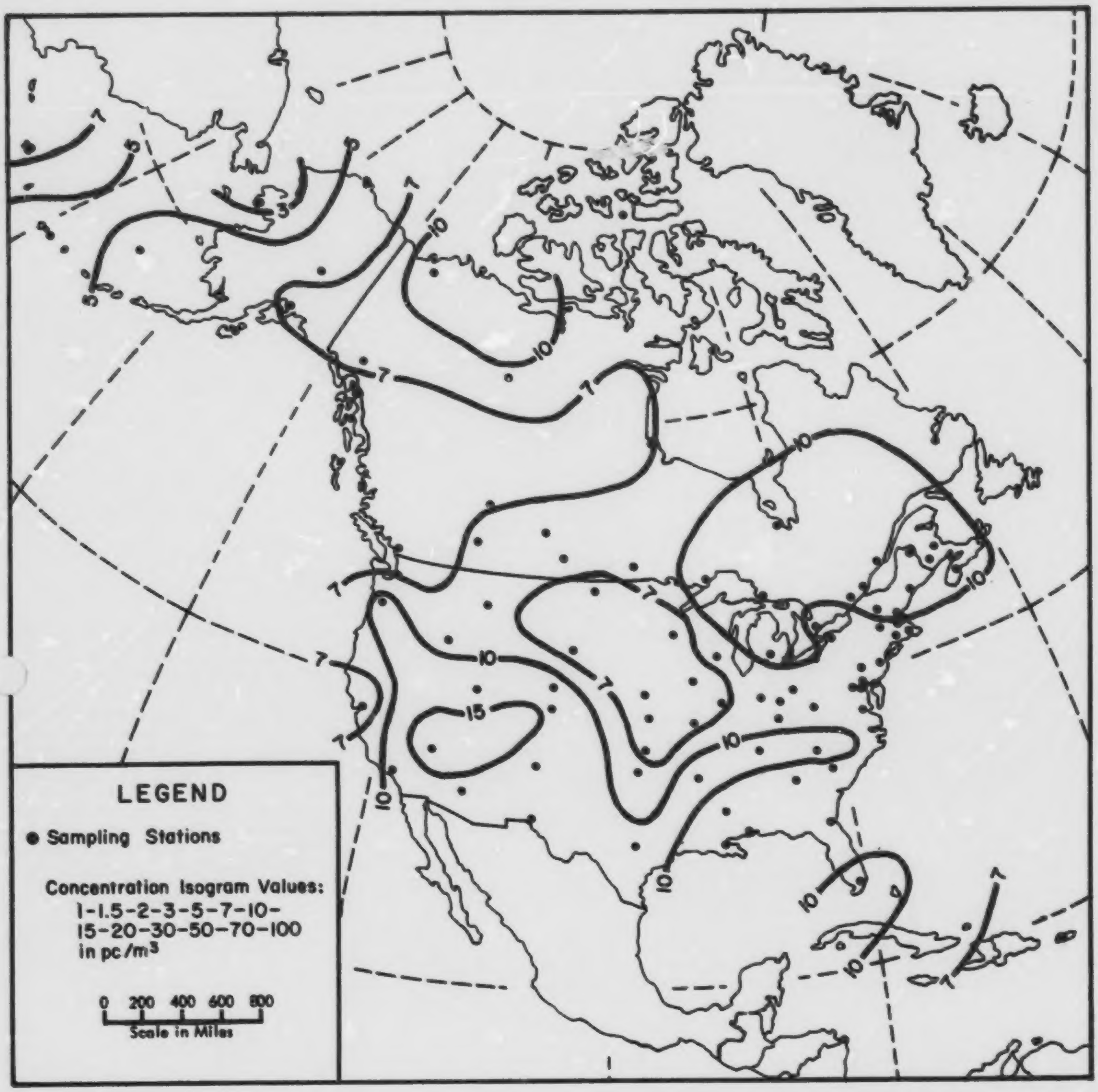
FIGURE 5.—AIRBORNE GROSS BETA CONCENTRATION CONTOURS FOR CANADA AND THE U. S., MARCH 1963


LEGEND
● Sampling Stations
Concentration Isogram Values:
1-1.5-2-3-5-7-10-15-20-30-50-70-100 in pc/m^3
0 200 400 600 800
Scale in Miles
3
5
7
10
15

Sr^{90}-Y^{90} standard. Four successive measurements are made on each filter to allow for the presence of natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for March 1963 are given in table 5 and presented in conjunction with U. S. adjusted air data by the isogram map (figure 5).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measure-

TABLE 6.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, RFSP, MARCH 1963

Station location	Total beta activity		Deposition of specific radionuclides for selected samples [a, b] (nc/m ²)				
	pc/liter	nc/m²	Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}
Calgary	2,012	29.2	2.46	0.23	4.77	0.47	0.19
Coral Harbour	[c]	24.6					
Edmonton	3,864	62.1					
Fredericton	1,466	128.8					
Ft. Churchill	1,941	23.1					
Ft. William	1,536	66.0					
Goose Bay	1,353	95.7					
Inuvik	1,114	25.1					
Montreal	2,679	233.3	17.7	1.42	24.4	2.10	0.90
Moosonee	3,284	79.0					
Ottawa	2,887	160.2					
Quebec	1,786	140.8					
Regina	3,983	20.6					
Resolute	3,907	101.2					
Saskatoon	3,300	53.0					
Sault St. Marie	2,136	147.2					
Shearwater	1,894	105.5					
Torbay	894	51.0					
Toronto	2,357	163.0					
Vancouver	3,186	236.1	16.5	1.38	32.2	2.85	0.83
Whitehorse	802	20.4					
Windsor	2,552	201.1					
Winnipeg	1,584	30.0	2.80	0.22	3.73	0.24	0.21
Yellowknife	1,909	13.9					
Average	2,279	92.1					

[a] All values corrected for decay back to end of collection month.
[b] Values for strontium-90, cesium-137, and zirconium do not include the activities of their daughter isotopes, yttrium-90, barium-137, and niobium-95.
[c] Trace precipitation.

ments on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample, and sent to the laboratory. March precipitation data for Canada, including some radiochemical analyses, are shown in table 6.

REFERENCES

(1) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW-RP-3*, Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4*, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) Mar, P. G.: *Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5*, Department of National Health and Welfare, Ottawa, Ca ada (December 1962).

(4) Beale, J. and J. Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program, RPD-11*, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5 Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RPD-21*, Department of National Health and Welfare, Ottawa, Canada (August 1962).

Recent coverage in *Radiological Health Data:*

Period	*Issue*
October 1962	*February 1963*
November 1962	*March 1963*
December 1962	*April 1963*
January 1963	*May 1963*
February 1963	*June 1963*

MEXICAN RADIOACTIVE FALLOUT PROGRAM
March 1963

Radiological Protection Program
National Commission of Nuclear Energy, Mexico

The Radiation Surveillance Network of Mexico was established by the Comisíon Nacional de Energía Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961 to provide a means for determining increased levels of radioactivity in air and precipitation due to fallout from nuclear tests.

Prior to the establishment of the network, two pilot sampling stations were set up in Mexico City and San Luis Potosí, to aid in the selection of equipment and sampling sites. Since April 1962 the network has been expanded to twelve stations, eleven of which were in operation by the end of March 1963 (see figure 6).

Seven of the twelve stations are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the RPP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de Mexico, the Chemistry Department of the University of Merida, the Instituto de Zonas Deserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency glass fiber filter, 6″ x 8″, using high volume samplers. After each 24-hour period, the filter is removed and forwarded via airmail to the Laboratorio de Desechos Radiactivos, CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters natural radioactivity. Data are not extrapolated to time of collection.

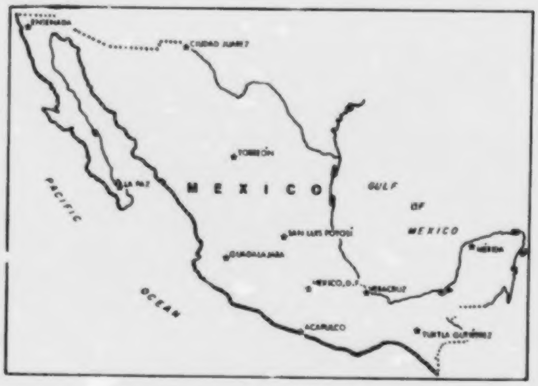


FIGURE 6.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

The maximum, minimum, and average fission product beta concentration in surface air during March 1963 are presented in table 7.

TABLE 7.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, MARCH 1963

[Concentration in pc/m³]

Station	Number	Maximum	Minimum	Average
Acapulco	7	7.75	3.81	5.19
Ciudad Juárez	11	66.81	4.12	18.19
Ensenada	4	12.03	4.46	9.19
Guadalajara	7	6.73	3.28	4.81
La Paz	17	11.84	4.34	7.01
Mérida	12	10.86	3.34	6.04
México, D. F.*	21	9.90	1.87	5.04
San Luis Potosí	13	14.30	2.45	7.58
Torreón	18	27.05	4.15	11.33
Tuxtla Gutiérrez	9	9.90	3.18	6.83
Veracruz	20	14.61	3.19	7.42

* Mexico City

4

Fission Product Gamma Activity in Airborne Particulates

In a recent proposal (*1*) submitted by the World Meteorological Organization (WMO), after consultation with the United Nations Scientific Committee on the effects of Atomic Radiation, the concept of air monitoring for fission products by gamma rather than beta counting was advanced. The method involves the simultaneous measurement of total gamma and of gamma over 1 Mev. Some theoretical advantages are cited for the use of gross gamma assay of air filters rather than the more customary gross beta measurement in Mr. Collins' report below.

The Health and Safety Laboratory has completed preliminary studies of gamma monitoring and has converted the 80th Meridian Network from beta to gamma measurement of each filter. These data will be reported on a monthly basis in *Radiological Health Data.*

THE 80TH MERIDIAN NETWORK
January 1963

William R. Collins, Jr.[1]

As of January 1, 1963, the Naval Research Laboratory (NRL) has withdrawn from the 80th Meridian air sampling program[2] to concentrate on certain research projects. Because of the value of the radioactivity in air measurements that the NRL had been making, the program has been continued by the Health and Safety Laboratory (HASL). The station locations are shown in figure 1.

Certain modifications have been made in the NRL system.[3] These include:

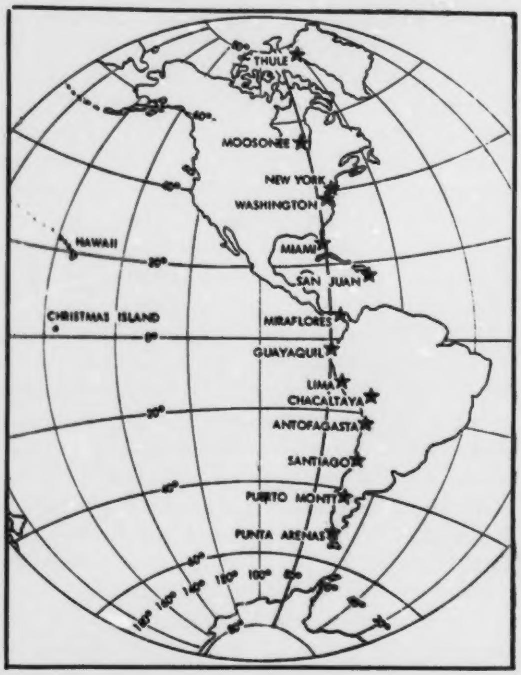


FIGURE 1.—ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (WEST)

1. Determination of gamma activity rather than beta activity for initial semi-quantitative measurements. This will be treated in detail below.
2. Substitution of Microsorban filters for the type 6 cellulose-asbestos paper previously used. Air volume has been increased from about 1200 to about 1300 m³. Experiments at NRL and at HASL have shown the two filters to be essentially equivalent. HASL considers Microsorban to be simpler to handle in the radiochemical analyses.
3. Addition of monthly ion exchange collectors to determine fallout deposition and to allow correlation of the two types of measurement.

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[1] Mr. Collins is a staff member of the U. S. Atomic Energy Commission's Health and Safety Laboratory in New York City.

[2] Monthly gross beta averages and profiles covering the period from November 1959 through December 1962 were reported monthly in *Radiological Health Data*—April 1960-April 1963. Results of the radiochemical analyses of the air filters for the calendar year 1960 and 1961 were presented in *RHD*—March 1962 and February 1963, respectively.

[3] These changes were effected on March 1 at the Northern Hemisphere stations and on April 1 at the stations in the Southern Hemisphere.

4. Setting dates for the start of the air filter sampling, as the 1st, 8th, 15th, and 22nd of each month. The new collection periods allow compositing of the individual air filter samples by months, to correspond with the deposition collector.

The most meaningful data from the 80th Meridian air sampling network are the results of the radiochemical analyses of the filters for individual radionuclides, such as strontium-90, cesium-137, and cerium-144. The chemical analyses, however, are quite laborious and lengthy; thus, there is frequently a lag of several months between the sampling period and the time at which results become available.

In an attempt to obtain more rapid semiquantitative results, the Naval Research Laboratory measured the total beta activity of the filters at a fixed time after sampling. This type of measurement gives good information on the arrival of airborne radioactivity and is the basis of a number of sampling networks in the United States and other countries. The single total beta measurement does not give information, however, on whether the radioactivity is of recent origin or is older material being collected at high concentrations because of meteorological factors. In addition, the standardization of counters for measuring total beta activity is quite difficult since the mixture of radionuclides emits beta particles with a wide range of energies.

In considering a suitable replacement for total beta activity measurements, the United Nations Scientific Committee on the Effects of Atomic Radiation has recommended the use of gamma activity measurements (*1*). With relatively simple gamma measuring equipment it is possible to measure both the total of all gamma rays from the sample and the fraction of those gamma rays having an energy above one million electron volts (>1 Mev). This latter gamma radiation is indicative of fresh fission products, particularly barium-lanthanum-140. With the two measurements it is possible to obtain the information on arrival of airborne activity and, in addition, to determine whether or not it contains fresh fission products.

The Health and Safety Laboratory has adopted this procedure for the rapid semiquantitative measurement of the 80th Meridian filters. Samples received at HASL are gamma counted on an 8″ x 4″ (20 x 10 cm) sodium iodide crystal, obtaining both total gamma activity and the fraction of the gamma activity with energies above 1 Mev. In addition, the filters, after gamma measurement of the weekly samples, will be grouped by months and subjected to radiochemical analysis.

One problem that remains is the comparison of data produced by the new system with earlier data produced by total beta counting. Since both of these are semi-quantitative methods it is not necessary to have an exact factor for converting one to the other and, in fact, this is not possible. Two quantities are needed for conversion. One is the factor for the counter efficiency which is the number of gamma counts per gamma photon. This factor has been measured for a number of gamma-emitting fission products and an average value of 0.35 has been adopted for the particular counting conditions used. The measured factors for a number of nuclides are given in table 1.

The second factor is the number of beta disintegrations per minute associated with the emission of a particular number of gamma photons per minute. This factor has been calculated for mixed fission products of different ages from the known abundances and radioactive properties of the individual fission products. These data are plotted in figure 2. It is evident that, for fission products ranging from 10 days to 4 months in age, the factor is about 1.5. Beyond that age the factor is variable, but if 3 is accepted, the error will be less than 50 percent.

It is possible to decide whether or not the average age of mixed fission products is less than 4 months. Measurements on the fission products in 93-percent enriched uranium-235, irradiated with thermal neutrons, were made over an extended period. Gamma over 1 Mev

TABLE 1.—PHOTON EFFICIENCIES FOR VARIOUS FISSION PRODUCTS

Radionuclide	Efficiency (counts per photon)
Ba^{140} - La^{140}	0.334
Cs^{137} - Ba^{137m}	0.439
I^{131}	0.359
Ce^{144} - Pr^{144}	0.301
Zr^{95} - Nb^{95}	0.316
Mean	0.350

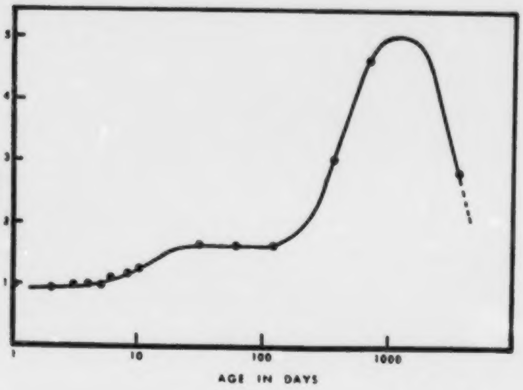

FIGURE 2.—BETA TO GAMMA RATIO AS A FUNCTION OF AGE OF FISSION PRODUCTS

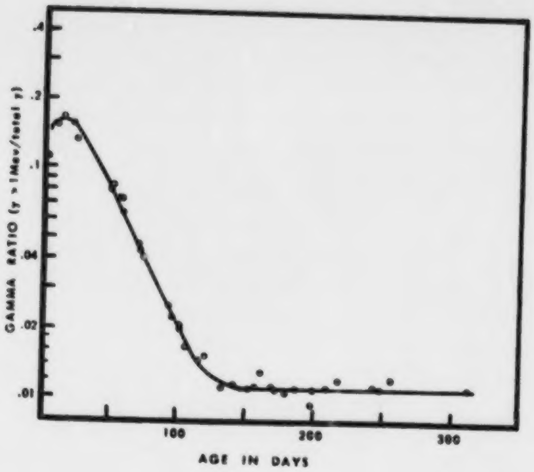

FIGURE 3.—FRACTION OF GAMMAS OVER 1 MEV AS A FUNCTION OF AGE OF FISSION PRODUCTS

and total gamma were measured, and the ratio of the resulting count rates is shown in figure 3. Fission products having an average age greater than 4 months show a fairly constant gamma ratio of 0.011, and younger fission products show a higher ratio.

In practice, the first step is to measure both the total gamma activity and the gamma activity above 1 Mev. From the ratio of the two measurements, the average age is determined. The total gamma count is then corrected for counter efficiency to give total gamma photons per minute. This is then multiplied by 1.5 for young fission products or 3 for older fission products to give an estimate of total beta activity.[4]

Table 2 lists a few comparative results for filters run at NRL for total beta activity and at HASL for total gamma activity with subsequent estimate of beta activity. The agreement between the two sets of values is better than expected and may not be typical.

It should be emphasized that the total beta activity obtained in this way is an estimate. It will be included in the 80th Meridian reports only to allow comparison with earlier measurements. The total gamma should be just as meaningful as total beta, and the most significant data will still be that based on radiochemical analysis.

The addition of ion exchange fallout collectors to the 80th Meridian Network sampling is intended to allow radiochemical comparison between airborne radioactivity and fallout deposi-

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[4] A further conversion to picocuries is made by dividing by 2.22 dpm/pc.

TABLE 2.—COMPARISON OF ESTIMATED AND MEASURED BETA ACTIVITIES

Sampling site	Sampling date	Calculated		Measured	
		Beta dpm (HASL)	Reference date (1963)	Beta dpm (NRL)	Reference date (1963)
Miraflores, Panama Canal Zone	Dec 24-31, 1962	79,800	Jan. 18	51,800	Jan. 25
Mauna Loa, Hawaii	Dec. 17-22, 1962	40,400	Jan. 18	40,000	Jan. 25
Washington, D. C.	Jan. 1963	116,000	Mar. 11	114,400	Mar. 26
		115,000	Mar. 11	85,000	Mar. 26
		163,000	Mar. 11	172,900	Mar. 26
San Juan, Puerto Rico	Nov. 26 - Dec. 12, 1962	42,600	Mar. 15	41,800	Mar. 21
	Dec. 3-13, 1962	49,500	Mar. 15	48,400	Mar. 21
	Dec. 17-24, 1962	86,900	Mar. 15	94,100	Mar. 21
	Dec. 24-31, 1962	44,200	Mar. 15	47,700	Mar. 21

TABLE 3.—ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, JANUARY 1963

Sampling station	Sampling period dates—noon to noon	Gamma activity (photons/min/m³)			Estimated total beta activity (pc/m³)
		Filter	Average for month	γ > 1 Mev to total γ ratio	
Thule, Greenland	1-8	6.16		0.035	4.2
76° 36'N	8-15	11.8		0.032	8.0
68° 35'W	15-22	14.2		0.047	9.6
Elev. - 259 meters	22-2/1	16.6	12.2	0.024	11.2
Moosonee, Canada	1-8	9.34		0.037	6.3
51° 16'N	8-15	4.05		0.033	2.7
80° 39'W	15-22	8.40		0.025	5.7
Elev. - 10 meters	22-2/1	8.14	7.50	0.026	5.5
New York, New York[a]					
40° 48'N					
73° 58'W					
Elev. - 38 meters					
Washington, D. C.	1-8	13.0		0.030	8.8
38° 58'N	8-15	8.20		0.043	5.5
77° 25'W	15-22	14.5		0.040	9.8
Elev. - 76 meters	22-2/1	23.8	14.9	0.021	16.1
Miami, Florida	1-7	18.9		0.025	12.8
25° 49'N	7-14	18.5		0.040	12.5
80° 17'W	14-21	6.54		0.026	4.4
Elev. - 4 meters	21-31	16.1	15.0	0.029	10.9
Mauna Loa, Hawaii	1-8	6.02		0.028	4.1
19° 28'N	8-15	7.73		0.030	5.2
155° 36'W	22-2/1	10.6	8.33	0.021	7.2
Elev. - 3,394 meters					
San Juan, Puerto Rico	1-8	12.6		0.031	8.5
18° 26'N	8-15	5.28		0.022	3.6
66° 00'W	15-22	13.3		0.032	9.0
Elev. - 10 meters	22-2/1	4.90	9.02	0.038	3.3
Miraflores, Panama	1-8	4.29		0.022	2.9
Canal Zone	8-15	6.57		0.038	4.4
90° 00'N	15-22	10.7		0.031	7.2
79° 35'W	22-2/1	10.5	7.90	0.028	7.1
Elev. - 10 meters					
Guayaquil, Ecuador[b]					
2° 10'S					
79° 52'W					
Elev. - 7 meters					
Lima, Peru	1-8	1.00		0.017	0.72
12° 06'W					
77° 01'W					
Elev. - 134 meters					
Chacaltaya, Bolivia	1-8	0.509		0.014	0.34
17° 10'S					
68° 15'W					
Elev. - 5,220 meters					
Antofagasta, Chile	1-8	0.734		0.017	0.50
23° 37'S	8-15	0.626		0.016	0.42
70° 16'W	15-22	1.16		0.071	0.78
Elev. - 519 meters	22-2/1	0.634	0.789	0.021	0.48
Santiago, Chile	1-8	0.687		0.027	0.46
33° 27'S	8-15	0.361		0.072	0.24
70° 42'W	15-22	0.525		0.021	0.36
Elev. - 520 meters	22-2/1	0.707	0.570	0.018	0.48
Puerto Montt, Chile	1-8	0.213		0.026	0.14
41° 27'S	8-15	0.279		0.042	0.19
72° 57'W	15-22	0.331	0.272	0.036	0.22
Elev. - 5 meters					
Punta Arenas, Chile	1-8	0.207		0.012	0.14
53° 08'S	8-15	0.292		0.020	0.20
70° 53'W	15-22	0.239		0.027	0.16
Elev. - 3 meters	22-2/1	0.159	0.234	0.034	0.11

[a] Scheduled to begin operation in March 1963.

[b] Data not available.

tion at a number of locations. This is presently being done only at a few research installations.

The amount of deposition collected in any given month is not large enough to allow gamma measurements, thus, these samples are analyzed radiochemically for strontium-90 and for strontium-89. These determinations will allow for some estimation of the age of the activity

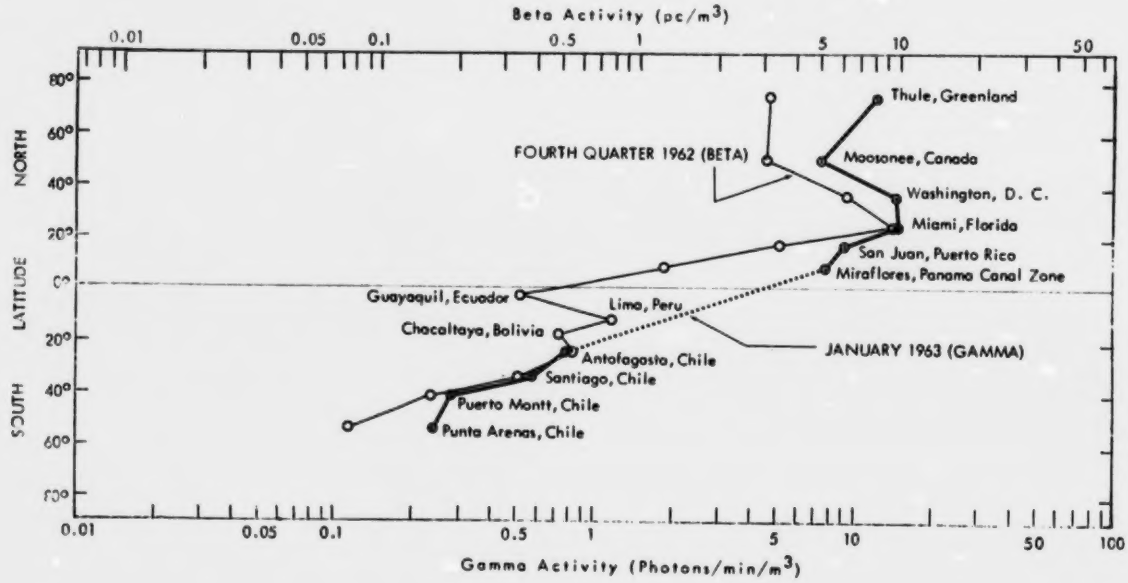

FIGURE 4.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, JANUARY 1963

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and can be compared with the same determinations made on the air filters.

With this report are presented the data available for the gamma activity measurements on air filters from the 80th Meridian Network for January 1963. The data are not complete due to some mislabeling of filters and problems involved in the changeover from NRL to HASL operation of the Network.

The results are shown in table 3 including the $\gamma > 1$ Mev/total γ ratio. In addition, the estimated total beta activity has been determined for comparison with previously published data. January 1963 averages for each station have been plotted in figure 4 as a gamma activity profile. [*Editor's note: A compariso with the fourth quarter 1962 average (from NRL) has been made in figure 4 by plotting the latter against a beta activity scale, which has been shifted to account for the dpm to pc conversion and an assumed beta to photon ratio of 1.5.*]

REFERENCE

(*1*) United Nations General Assembly, Seventeenth Session: *Agenda Item 30, Report of the United Nations Scientific Committee on the Effects of Atomic Radiation—Report of the World Meteorological Organization on the Implementation of General Assembly Resolution 1629* (XVI), New York (October 8, 1962).

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SECTION II.–FOOD

Radionuclides in Institutional Diet Samples
October-December 1962

Division of Radiological Health,
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is being administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selective population group ranging from children to young adults of school age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 21 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from financially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (sampling point) is located in a community monitored by the PHS Pasteurized Milk Network. The analytical data from this program supplement the findings for the Institutional Diet Sampling Program.

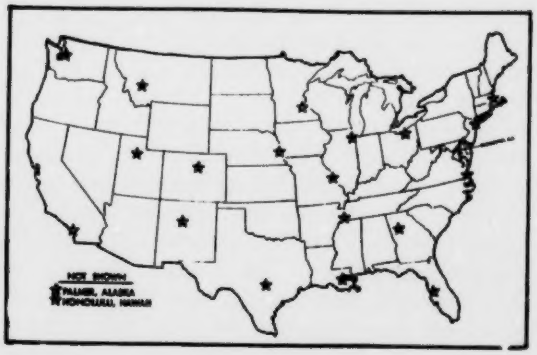

FIGURE 1.—INSTITUTIONAL DIET SAMPLING LOCATIONS, DECEMBER 1962

TABLE 1.—INSTITUTIONAL DAILY DIETARY

Data	Month (1962)	Alaska, Palmer	California, Los Angeles	Colorado, Denver	Florida, Tampa	Georgia, Atlanta	Hawaii, Honolulu	Louisiana, New Orleans	Massachusetts, Boston	Minnesota, Minneapolis	Montana, Helena
Age (years)		6-18	6-18	6-18	1-15	6-18	5-16	4-19	—	[a]< 1-16	4-16
Total weight (kg/day)	Oct.	2.16		2.01	1.79	1.72	1.72	2.50	1.54	1.64	2.74
	Nov.	1.64	1.19	1.88		1.82		2.49	1.52	1.50	
	Dec.	1.24	1.31	2.33	1.83	1.82	1.89	2.19	1.75	1.50	1.97
Calcium (g/day)	Oct.	1.5		1.2	1.1	0.8	0.7	1.8	0.9	0.9	1.6
	Nov.	0.9	0.9	0.6		1.0		1.6	1.1	1.1	
	Dec.	1.1	0.8	2.6	1.1	7.2	0.8	1.4	1.4	0.4	1.1
Phosphorus as phosphate (g/day)	Oct.	6.9		5.0	3.8	3.6	3.5	5.6	3.8	3.2	7.2
	Nov.	3.9	4.0	3.0		4.0		6.5	3.5	5.3	
	Dec.	3.6	3.3	16.3	4.6	4.9	3.3	6.6	4.7	3.2	4.5
Potassium (g/day)	Oct.	3.5		3.3	2.1	0.8	2.1	4.1	3.1	2.3	3.8
	Nov.	4.1	1.9	2.8		2.2		3.7	6.6	1.7	
	Dec.	1.6	1.8	6.1	3.0	2.2	2.3	3.4	3.5	1.7	3.0
Total radium (pc/day)	Oct.	1.0		3.0	< 2.0	< 2.0	11.0	4.0	< 1.0	< 1.0	< 1.0
	Nov.	2.0	2.0	4.0		2.4		3.8	1.0	< 1.0	
	Dec.	4.0	2.0	5.0	2.0	< 2.0	5.0	< 3.0	< 1.0	< 1.0	3.0
Strontium-89 (pc/day)	Oct.	100		200	< 10	< 10	15	< 20	35	85	50
	Nov	30	10	5		30		< 15	25	130	
	Dec.	25	10	40	20	160	25	45	20	10	15
Strontium-90 (pc/day)	Oct.	37		20	14	18	6	43	14	20	21
	Nov.	21	10	13		12		31	14	3	
	Dec.	21	3	57	12	17	12	28	16	9	16
Cesium-137 (pc/day)	Oct.	110		100	70	< 10	25	100	100	65	60
	Nov.	70	5	85		35		75	180	60	
	Dec.	20	20	235	120	55	65	110	205	55	80
Barium-140 (pc/day)	Oct.	< 10		< 10	< 20	< 20	< 10	< 30	10	< 10	< 10
	Nov.	< 10	< 10	< 10		< 20		< 30	< 10	< 10	
	Dec.	< 10	< 10	< 10	< 20	< 20	< 10	< 30	60	< 10	< 10
Iodine-131 (pc/day)	Oct.	< 10		< 10	< 20	50	50	< 30	20	< 10	< 10
	Nov.	390	< 10	< 10		< 20		30	< 10	< 10	
	Dec.	< 10	< 10	70	< 20	< 20	< 10	70	45	< 10	< 10

[a] Food samples not collected for children too young for solid diet.

Sampling Procedure

In general, the sampling procedure is the same in each case. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Each day's sample is kept frozen during the collection period. After compositing the total sample, it is packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

Each sample is packaged in three containers: One containing solid food minus seeds, pits, rinds, shells and bones that would not ordinarily be eaten; one containing dairy products such as milk, cottage cheese, and ice cream; and one containing soft drinks, coffee and tea. A record of the contents of each meal and the approximate weight of each item is made by the institution's dietician and sent with the sample. Samples usually range from 6 to 16 liters in volume and weigh from 8 to 20 kilograms.

Analytical Procedures

Total weight, stable calcium, and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods. Phosphate determinations are made by a colorimetric technique. Because calcium and phosphorus compounds may have an effect on the uptake of important boneseeking radionuclides such as strontium-89 and strontium-90 (*2*), they are included in the analytical program.

The radioanalysis program is designed around three basic procedures: (1) gamma spectroscopy, (2) chemical separation of strontium-89 and strontium-90 with subsequent counting, and (3) total radium analysis. In the absence of

INTAKE (BASED ON A 7-DAY COMPOSITE SAMPLE)

Data	Month (1962)	Nebraska, Omaha	New Mexico, Albuquerque	Ohio, Cleveland	Tennessee, Memphis	Texas, Austin	Utah, Salt Lake City	Virginia, Norfolk	Washington, Seattle	Monthly minimum average	Monthly maximum average
Age (years)		6-8	5-14	6-15	8-18	6-18	12-18	10-18	6-16	—	—
Total weight (kg/day)	Oct.	1.65	1.77	1.80	1.39	2.57	1.33	1.17	2.27	1.87	1.87
	Nov.	1.63	1.72	1.73	1.17	3.35	1.59	1.17	2.83	1.82	1.82
	Dec.	1.05	1.62	1.77	1.06	2.29	1.35	1.34	2.61	1.62	1.62
Calcium (g/day)	Oct.	1.3	1.7	1.5	1.1	1.2	1.0	0.6	3.2	1.3	1.3
	Nov.	0.8	1.1	1.5	0.9	1.8	1.4	0.6	2.0	1.2	1.2
	Dec.	0.8	1.4	1.3	0.7	1.1	1.0	0.7	2.1	1.2	1.3
Phosphorus as phosphate (g/day)	Oct.	4.8	3.9	4.8	3.4	5.3	3.8	2.5	5.7	4.5	4.8
	Nov.	5.6	4.9	4.0	3.0	7.7	3.6	2.7	7.7	4.7	4.7
	Dec.	5.6	5.3	4.8	2.9	5.2	3.1	3.3	5.9	4.2	5.2
Potassium (g/day)	Oct.	2.8	3.2	7.5	2.4	3.2	2.1	1.5	1.4	2.9	2.9
	Nov.	2.0	2.4	6.0	2.0	4.9	2.5	1.7	4.8	3.3	3.3
	Dec.	2.0	3.1	3.2	1.7	3.4	2.2	2.0	3.7	2.8	2.8
Total radium (pc/day)	Oct.	< 1.0	2.0	3.0	1.4	2.9	< 1.0	< 2.0	4.0	1.8	2.5
	Nov.	2.0	2.0	2.0	1.3	< 4.0	6.0	1.5	< 1.0	2.0	2.4
	Dec.	2.0	2.0	2.0	< 2.0	< 2.0	3.0	< 2.0	8.0	2.1	2.8
Strontium-89 (pc/day)	Nov.	65	35	< 5	< 10	< 15	35	< 10	115	43	48
	Oct.	25	25	15	25	60	50	40	115	39	40
	Dec.	25	40	40	25	35	35	45	145	42	42
Strontium-90 (pc/day)	Oct.	19	11	2	19	15	8	15	17	18	18
	Nov.	9	8	12	10	16	12	9	64	16	16
	Dec.	9	8	5	11	16	9	16	44	17	17
Cesium-137 (pc/day)	Oct.	40	25	100	15	50	65	40	90	63	64
	Nov.	35	< 10	80	25	135	85	35	110	72	73
	Dec.	35	40	140	25	90	75	45	155	90	90
Barium-140 (pc/day)	Oct.	< 10	< 10	< 10	< 20	< 30	< 10	< 20	< 10	< 1	15
	Nov.	10	< 10	10	< 20	< 40	< 10	< 20	< 10	1	15
	Dec.	10	110	30	< 20	< 30	< 10	< 20	< 10	12	24
Iodine-131 (pc/day)	Oct.	< 10	320	< 10	< 20	< 30	< 10	10	< 10	26	37
	Nov.	< 10	< 10	20	20	70	< 10	< 20	< 10	35	43
	Dec.	< 10	160	70	30	70	< 10	< 20	< 10	29	36

interferences other than naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for the gamma scan on a per-kilogram basis are: I-131, 10 pc/kg; Cs-137, 5 pc/kg; and Ba-140, 10 pc/kg. Approximate minimum detectable concentrations for Sr-89, Sr-90, and total radium are: 5, 1, and 1 pc/kg, respectively.

Total radium is determined by ashing, separation, and coprecipitation of radium as sulfate or chromate. After transfer to planchets and drying, alpha activity is measured by an internal proportional counter with an appropriate delay for checking ingrowth of radium daughters. Since naturally-occurring radionuclides may contribute to the reported total radium values, the total radium technique is a practical screening indicator only. The bone dose, calculated by assuming total radium to be only radium-226, would therefore be moderately high.

Data

Table 1 presents the dietary intake data expressed on a per-day basis from October 1962 through December 1962 for the 18 institutions from which samples were received. The reported iodine-131 values are based on the iodine-131 content of the sample at the end of the sample collection period. Therefore, the true iodine-131 intakes may be somewhat greater than the reported values.

Certain of the radioanalyses are reported by the laboratories as being "less than" (<) a specified value. For data averaging, the method employed for presentation in table 1 is that all "less-than" data are assumed to be equal to the full "less-than" values as they appear in the column entitled "monthly maximum averages." The column entitled "monthly minimum averages" reflects the averages in which all "less than" values are considered to be zero.

Strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 averages of the daily intakes at the institutions, as well as announced atmospheric nuclear detonations for 1961 and 1962, are shown in figure 2.

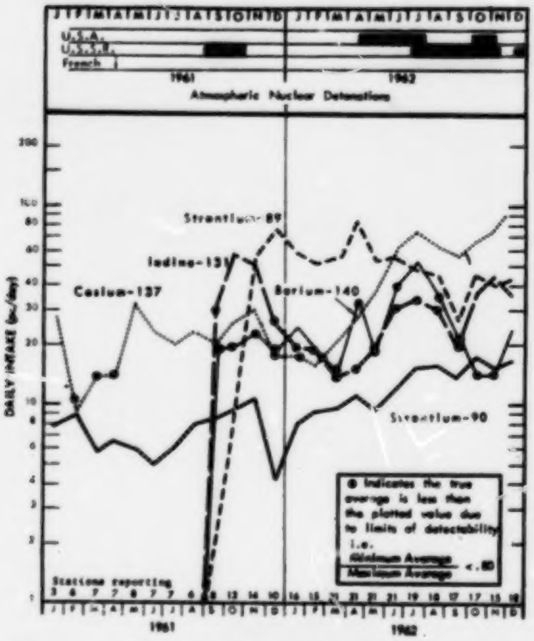

FIGURE 2.—RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES—AVERAGE OF INSTITUTIONS

For rapid comprehension, the data are presented graphically in figures 3-10 as station distributions versus daily intake. These are not graphs of continuous functions as might be inferred from their appearance. For example, in figure 3 total dietary intake of food is divided into six ranges (< 1.00, 1.00-1.49, 1.50-1.99, 2.00-2.49, 2.50-2.99 and 3.00-3.50 kg/day), and the number of institutions in each range is noted and plotted as a bar graph. The maximum of each bar is connected by a smooth curve. This type of construction is used for each month for each item represented.

The number of stations used in constructing these graphs was 17, 15, and 18 for the months of October, November and December 1962, respectively. It is, of course, acknowledged that a variation of two institutions may not be significant in considering trends in the data.

Discussion of Data

During the 3-month period reported, the dietary intake of strontium-90 ranged between 2 and 64 pc/day, with 38 of 50 institution-months * being in the lowest Federal Radiation Council (FRC) Range of Transient Rates of intake. The lowest Range established by the FRC is 0 to 20 pc/day for strontium-90 (*3,4*).

The strontium-89 distribution (figure 8) shows that the majority of institutions reported values below 40 pc/day. The lowest FRC Range for strontium-89 is 0 to 200 pc/day (*3*).

The dietary intake of total radium ranged between < 1.0 and 12.0 pc/day with 96 percent of the institution-months being 6.0 pc/day or less. Assuming the radium-226 component to be one-third of the total radium activity (*3*), the intake of radium-226 via the diet probably approaches the top of FRC Range I (0 to 2 pc/day for radium-226) at a few institutions.

Following the resumption of nuclear weapons testing in the atmosphere in 1961, iodine-131 dietary intake increased from nondetectable levels to an institutional high of 390 pc/day. This value occurred during October-December 1962, but only three institution-months were greater than 100 pc/day. FRC Range II for iodine-131 is 10-100 pc/day (*3*).

The cesium-137 dietary intake has ranged from < 5 to 235 pc/day during the period reported. The distribution of institutions (figure 10) is relatively flat from 0 to 120 pc/day. All institutions showed an increase in the cesium-137 intake during this quarter. This can be seen in the average of institutions graph, figure 2.

The distributions of total weight intake of food for this quarter (figure 3) are similar to those for the previous period. The total weight of food consumed ranged between 1.06 and 3.35 kg/day, with most institutions reporting between 1 and 2 kg/day.

The calcium intake average of institutions (table 1) has normally ranged between 1.0 and 1.3 g/day while the calcium distribution (figure 4) usually has a well-defined peak. This quarter's results for calcium follow this same pattern.

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* An institution-month is one datum value per institution per month. (e g., 20 institutions reporting one value per month for 3 months is 60 institution-months).

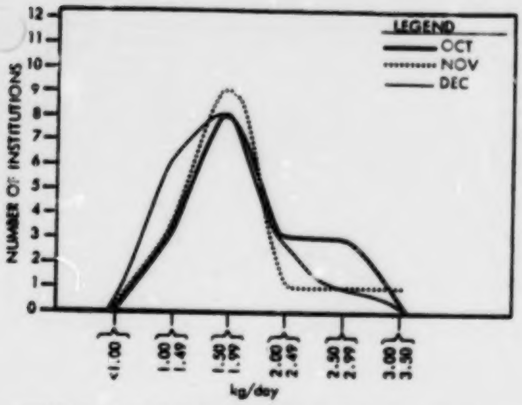

FIGURE 3.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS TOTAL DAILY DIETARY INTAKE ON A WEIGHT BASIS

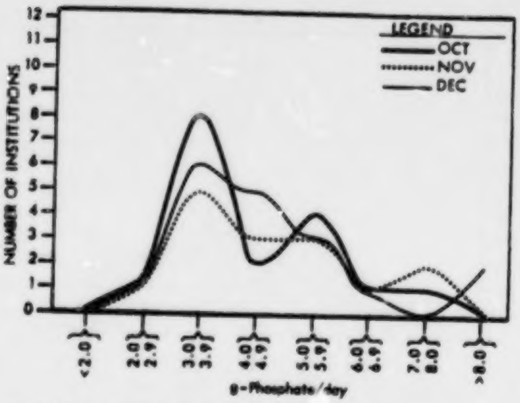

FIGURE 6.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY PHOSPHATE INTAKE

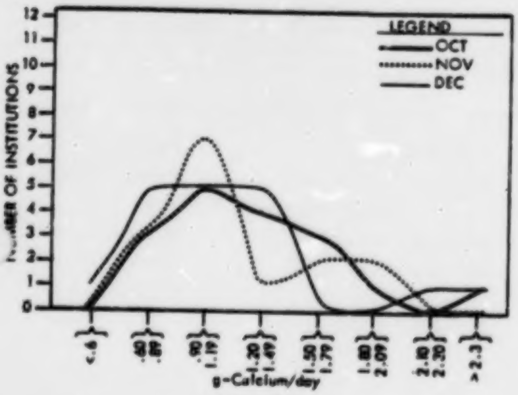

FIGURE 4.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY CALCIUM INTAKE

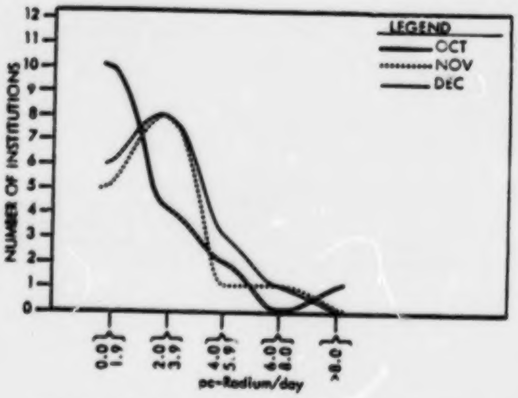

FIGURE 7 -- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY TOTAL RADIUM INTAKE

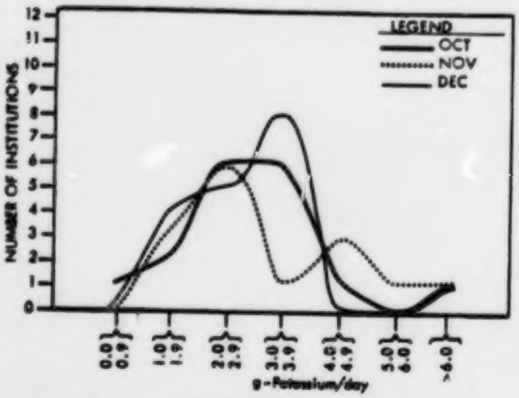

FIGURE 5 -- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY POTASSIUM INTAKE

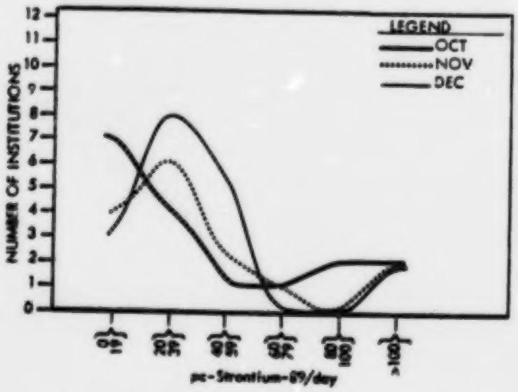

FIGURE 8-- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY STRONTIUM-89 INTAKE

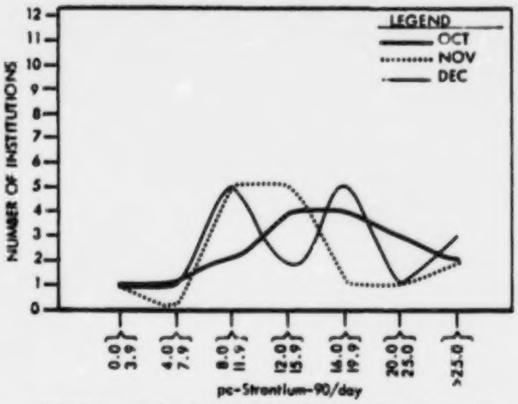

FIGURE 9.— DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY STRONTIUM-90 INTAKE

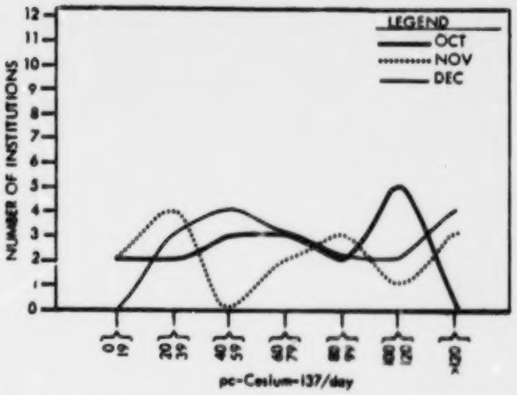

FIGURE 10.— DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY CESIUM-137 INTAKE

REFERENCES

(*1*) Anderson, E. C., and D. J. Nelson, Jr.: Surveillance for Radiological Contamination in Foods, *American Journal of Public Health, 52:* 1391-400 (September 1962).

(*2*) Chen, P. S., Jr., A. R. Terepka, and H. C. Hodge: The Pharmacology and Toxicology of the Bone Seekers, *Annual Review of Pharmacology 1*:369-96 (1961).

(*3*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2,* Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (September 1961), price 20 cents.

(*4*) Chadwick, Donald R. and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data, 3:* 159-65 (May 1962).

Previous coverage in *Radiological Health Data:*

Period	*Issue*
January-August 1961	*February 1962*
January 1961-February 1962	*July 1962*
March-June 1962	*December 1962*
July-September 1962	*April 1963*

Selected Results From Total Diet Studies *

May 1961-June 1962

Since November 1959, the Consumers' Union (CU) has engaged in studies of the radionuclide content of samples of teen-agers' total diet collected at various periods of the year from groups of selected U. C. cities (*1-5*). It is believed that the selection of the teen-ager group for study will produce estimates of dietary radionuclide intake which are not likely to be exceeded by the general population. A basis for this is found in the National Research Council's recommended dietary allowances (*6*), which establish the relatively high nutritional needs of teen-agers as compared with other age groups.

Originally, diet samples from 25 U. S. cities were analyzed; as of the January 1962 sampling, the number of cities included was increased to 30. Of the original group of 25 cities sampled in November 1959, 5 cities have been included in all succeeding samplings, and dating from the May 1961 sampling, 10 cities have been consistently sampled among the 30 selected cities (figure 1). Beginning with the January 1962 sampling, two groups of 10 cities each have been included on an alternating basis with the basic group of 10 cities. Thus, each sampling from January 1962 through June 1962 includes 20 cities. This report presents CU teen-age diet data for the period from May 1961 through June 1962. Consumers' Union infant diet data from selected cities for the period June 1961 through June 1962 are also presented.

Sampling Procedures

Each diet sample from a city consisted of the total diet (food, milk, and drinking water) of teen-agers for a full week (21 meals plus snacks). To help assure that the various diet samples, though consisting of the same kinds of foods, would be as representative of the diet in the region in which a selected city was situated, home economists in universities were asked to prepare (on the basis of local surveys) diets as nearly identical as possible in composi-

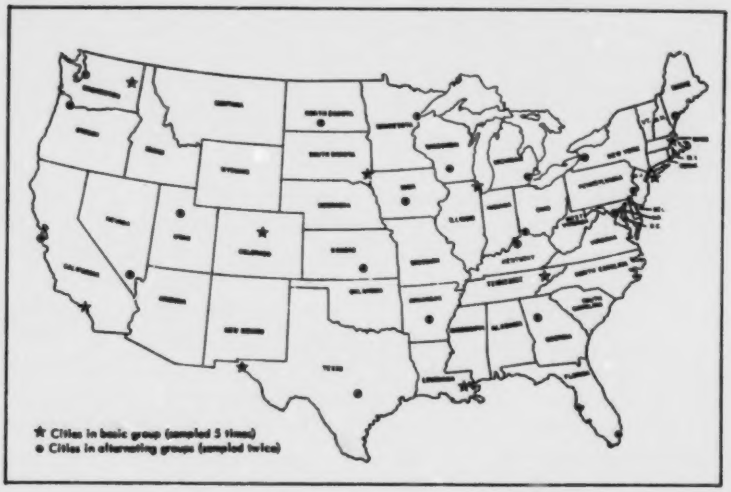
★ Cities in basic group (sampled 5 times)
● Cities in alternating groups (sampled twice)

FIGURE 1.—CONSUMERS' UNION DIET SAMPLING LOCATIONS, MAY 1961-JUNE 1962

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* Based on data from studies performed by Mr. Irving Michelson, Director of Public Service Projects, Consumers' Union, in fulfillment of Public Health Service contracts SAph 76694 and PH 86-62-82. Analyses were done by Isotopes, Inc., Westwood, New Jersey.

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TABLE 1.—TEEN-AGER AVERAGE DAILY DIETARY INTAK

Sampling location		Weight (kg/day)					Calcium (g/day)				
		May 1961	January 1962	March 1962	May 1962	June 1962	May 1961	January 1962	March 1962	May 1962	June 1962
Ark:	Little Rock		2.61		3.09			0.84		0.68	
Calif:	Los Angeles [a]	3.03	4.37	3.33	3.26	3.76	1.32	1.75	1.66	1.43	1.77
	San Francisco		3.64		4.06			2.29		1.18	
Colo:	Denver [a]	2.97	3.34	3.37	3.39	3.10	1.69	1.77	1.89	2.00	1.30
D. C:	Washington		3.34		3.27			1.77		1.60	
Fla:	Miami			3.94		3.20			2.21		1.50
Ga:	Atlanta		3.48		3.47			1.91		1.94	
Ill:	Chicago [a]	3.68	3.74	4.00	3.87	4.11	1.69	2.02	2.24	2.21	2.01
Ky:	Louisville			3.87		2.34			2.28		1.01
Kans:	Wichita			3.51		3.88			2.18		1.99
La:	New Orleans [a]	2.54	3.57	3.53	3.64	3.73	0.76	2.14	2.22	1.93	2.09
Maine	Portland			3.56		3.86			1.57		1.50
Mass:	Boston [a]	4.59	5.84	4.00	5.39	5.41	2.20	2.16	2.20	2.80	2.76
Mich:	Detroit		3.50	3.34	3.21	3.91		1.96		1.73	
Minn:	Duluth								1.64		1.80
Nev:	Las Vegas			3.96		3.50			2.14		1.92
N. Dak:	Bismarck		3.96		3.91			2.10		1.84	
N. Y:	Buffalo		3.14		3.97			1.63		2.14	
	New York [a]	3.39	3.40	3.77	3.56	3.58	1.73	1.63	2.00	2.06	2.15
Ohio	Cincinnati			3.54		3.86			1.84		1.71
Ore:	Portland		3.44		4.06			1.65		1.91	
Pa:	Philadelphia			4.17		4.44			2.34		2.58
S. Dak:	Sioux Falls [a]	3.48	3.21	3.29	3.51	3.61	1.78	2.18	2.01	2.14	1.98
Tenn:	Knoxville [a]	3.51	3.88	3.40	3.38	3.56	1.56	2.52	2.11	2.33	2.03
Tex:	Austin			3.70		3.83			1.89		2.41
	El Paso [a]	3.49	3.51	3.54	3.51	3.18	1.68	2.55	2.27	2.18	2.00
Utah	Salt Lake City		2.66		2.19			1.46		1.07	
Wash:	Seattle			4.24		4.31			2.29		2.20
	Spokane [a]	3.44	3.58	3.51	3.61	3.04	1.89	2.54	2.25	2.24	1.52
Wis:	Madison		3.77		3.57			2.07		2.14	
Average (arithmetic)		3.41	3.60	3.68	3.59	3.66	1.63	1.95	2.06	1.88	1.91
10-city average [a]		3.41	3.84	3.57	3.72	3.71	1.63	2.13	2.09	2.13	1.96

[a] These cities were used in constructing figure 2 (a-c), since complete data for these cities are available.
[b] Strontium-89 not detectable in May 1961.

tion and weight to the average local diet of male teen-agers with healthy appetities. The home economist purchased in local markets fresh produce when available, and when necessary chose frozen and canned items as substitutes. A variety of brands of each item was also brought.

Typical items in the menus were hot and cold cereal, eggs, bread, milk and other dairy products, spaghetti, beef, lamb, pork, chicken, fish, salads, vegetables, soups, fruits, fruit juices, and drinking water. Also included were snacks containing soft drinks, candy, cookies, sandwiches, cake, and ice cream. Meals were prepared, including cooking and seasoning, as they would be for actual consumption. Inedible parts, such as bones, excess fats, skins, shells, pits, and cores were discarded. After preparation, the samples were shipped to the CU contract laboratory for analysis. Selected samples were sent to Public Health Service (PHS) laboratories for cross-checking.

In addition to these analyses, for the 10 cities which were consistently sampled, separate milk samples which were representative of the milk in the total diet samples were analyzed to determine the contribution of this item to the total dietary intake.

Analytical Program and Methods

The 1961 program included analyses of each sample for cerium-144, cesium-137, zinc-65, radium-226, potassium-40, strontium-90, and stable calcium. The 1962 program, which was conducted following the resumption of weapons testing, was designed to obtain data on concentrations of strontium-89, strontium-90, cesium-137 and stable calcium. The milk samples from ten cities were also analyzed for iodine-131. Both programs provided for the preparation of split samples as a check on the analytical procedures.

The calcium analysis has been derived from a procedure described by Yalman and Boulgerman (7). Strontium-90 was determined by beta counting its daughter yttrium-90 which had been chemically separated from the sample.

AVERAGE BASED ON SEVEN DAYS) MAY 1961 - JUNE 1962

Strontium-89 (pc/day)					Strontium-90 (pc/day)					Cesium-137 (pc/day)				
May 1961	January 1962	March 1962	May 1962	June 1962	May 1961	January 1962	March 1962	May 1962	June 1962	May 1961	January 1962	March 1962	May 1962	June 1962
[b]	26		70			8.6		16.4			29		66	
	8	121	17	15	5.7	14.4	12.0	4.6	6.0	16	52	47	23	94
	41		54			6.9		11.8			29		53	
	30	3.	35	42	8.4	11.4	9.4	15.9	15.9	22	27	40	51	81
	42		95			14.4		16.0			27		49	
		95		22			12.6		10.9			126		102
	96		141			26.4		23.0			35		142	
	40	[c] 4	6	112	9.6	12.3	16.8	12.4	21.4	45	37	60	46	127
		23		30			19.0		16.6			39		44
		[c] 7		148			16.1		29.4			25		112
	493	537	305	284	8.5	35.8	51.5	48.8	72.4	40	107	159	158	325
		[c] 4		65			18.9		34.4			61		154
	12	8	5	67	20.7	30.4	32.4	30.7	45.4	77	[d] —	40	75	179
	11		124			11.9		12.5			21		46	
		23		177			11.7		46.9			53		285
		42		32			7.5		9.8			44		32
	[c] 5		19			12.3		18.0			36		51	
	6		4			13.5		22.6			31		48	
	29	[c] 4	6	122	12.2	12.6	18.1	24.2	30.4	28	51	57	68	182
		37		128			13.1		24.9			46		144
	21		129			11.4		32.5			34		282	
		32		56			17.1		43.5			88		160
	25	25	83	212	10.2	10.6	11.8	14.4	36.5	26	32	43	77	141
	59	168	206	186	16.4	21.0	26.2	46.0	35.6	41	39	63	148	167
		61		[c] <15			14.8		39.3			52		123
	43	54	36	22	6.3	10.9	16.3	8.1	15.6	30	21	28	25	88
	15		16			6.9		6.4			21		26	
		29		125			14.4		40.5			59		228
	[c] 4	15	43	51	12.6	16.8	12.3	20.9	21.6	47	43	49	40	100
	25		36			11.3		13.6			38		64	
	51.5	66.0	68.7	90.6	11.1	15.0	17.5	20.1	30.0	37.2	37.5	59.2	75.0	131.9
	74.3	96.6	69.2	101.3	11.1	17.6	20.7	22.6	30.4	37.2	45.4	59.1	70.1	132.4

[c] Less-than values were used as the whole number in computing the strontium-89 average.
[d] Unusually high values obtained, not verified by correlation samples.

Strontium-89 was differentially estimated by beta counting the total radio-strontium in the sample. Cesium-137 determinations were made by beta counting after chemical separation.

Sampling Results

Table 1 presents strontium-89, strontium-90, and cesium-137, plus total weight consumed and stable calcium results. The total weight of food consumed ranged between 2.19 and 5.84 kilograms/day, with most intakes falling between 3 and 4 kilograms/day. The daily calcium intake ranged between 0.68 and 2.80 grams/day, with about 80 percent of the intakes falling between 1.5 and 2.5 grams/day.

Strontium-89 intake averages for the selected 10 cities are plotted in figure 2a. The average increased by about 33 percent between January 1962 and June 1962. It can be observed in table 1 that New Orleans consistently reported higher levels than the other cities. The maximum value reported for New Orleans was 537 pc/day in March 1962.

The strontium-90 intake values observed during the study ranged between 4.6 and 72.4 pc/day. The average of the 10 selected cities increased from 11.1 pc/day in May 1961 to 30.4 pc/day in June 1962 (figure 2b). Highest levels were noted in New Orleans, and lowest levels were observed in Los Angeles and El Paso. The highest value, 72.4 pc/day, occurred in June 1962.

The 10-city average for cesium-137 increased gradually from May 1961 to May 1962 and turned sharply upward in June 1962 (figure 2c). A high value of 325 pc/day was observed in New Orleans in June 1962.

Table 2 presents data on additional radionuclide values obtained for the basic group of 10 cities during the May 1961 sampling. Among these radionuclides, potassium-40 and radium-226 occur naturally in the diet, and cerium-144 is a fission product. The highest intake of stable potassium, as well as the highest value for potassium-40, was noted at Boston. The highest cerium-144 intake, 3.0 pc/day, occurred at New Orleans. The peak intake of

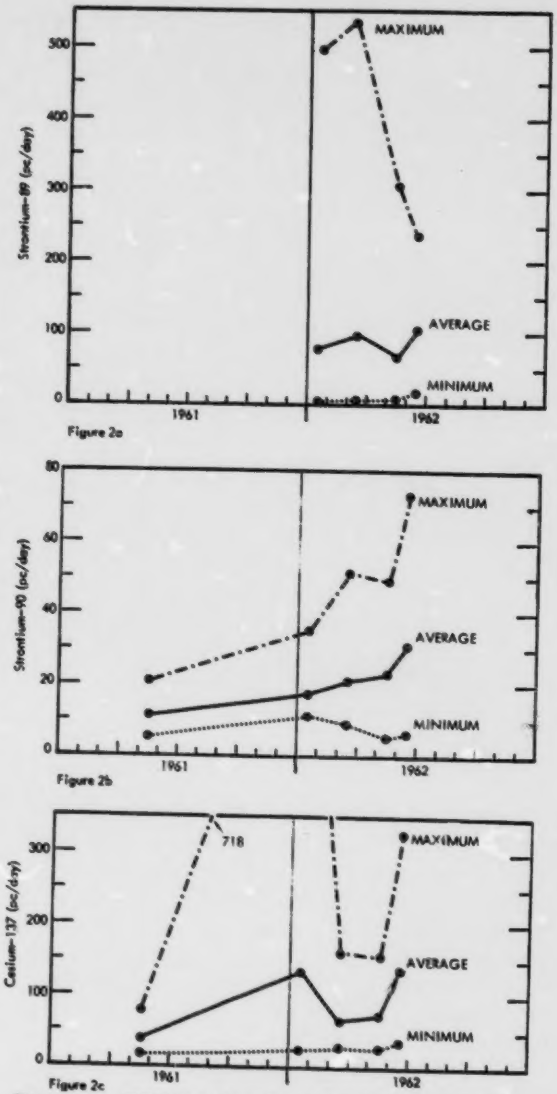

Figure 2a

Figure 2b

Figure 2c

FIGURE 2.—TEEN-AGER DAILY DIETARY INTAKE (TEN STATIONS WERE USED IN CONSTRUCTING THIS FIGURE, SEE FOOTNOTE a, TABLE 1)

radium-226 (5.1 pc/day) occurred at Boston.

In addition to teen-age diets, infant (one-year-olds) diets were sampled by the same procedure used for the former. The results of this study are shown in table 3. As would be expected, the weights of food consumed were considerably less, ranging between 1.14 and 2.33 kilograms/day. Correspondingly, the calcium intake ranged between 0.8 and 1.77 grams/day. Although only limited comparisons between the averages of groups of different cities (shown in table 3) may be made, it may be observed that the average strontium-89, strontium-90, and cesium-137 intakes increased from March 1962 to June 1962.

TABLE 2.—TEEN-AGER DIETARY DAILY INTAKE, MAY 1961

Sampling location		Potassium (g/day)	Potassium ^{40} (pc/day)	Cerium ^{144} (pc/day)	Radium ^{226} (pc/day)
Calif:	Los Angeles	3.6	3.100	1.5	1.5
Colo:	Denver	4.8	4,000	1.2	2.1
Ill:	Chicago	6.2	5,300	1.8	3.3
La:	New Orleans	3.5	2,900	3.0	2.0
Mass:	Boston	7.1	6,100	2.8	5.1
N.Y:	New York	3.8	3,100	2.0	2.4
S. Dak:	Sioux Falls	5.4	4,600	1.4	1.8
Tenn:	Knoxville	5.5	4,700	1.8	1.8
Tex:	El Paso	4.9	4,200	2.4	1.8
Wash:	Spokane	4.2	3,600	1.7	1.7
Average		4.9	4,160	2.0	2.4

TABLE 3.—INFANT AVERAGE DAILY DIETARY INTAKE (AVERAGE BASED ON SEVEN DAYS) JUNE 1961-JUNE 1962

Sampling location and date		Weight (kg/day)	Calcium (g/day)	Strontium-89 (pc/day)	Strontium-90 (pc/day)	Cesium ^{137} (pc/day)
June 1961						
Calif:	Los Angeles	1.57	0.97		1.6	8
Colo:	Denver	2.17	0.85		4.8	16
Ill:	Chicago	2.30	1.24		6.4	25
La:	New Orleans	1.74	1.34		20.1	33
Mass:	Boston	1.59	1.30		11.8	39
N.Y:	New York	1.67	1.77		9.5	44
S. Dak:	Sioux Falls	2.21	1.37		7.9	26
Tenn:	Knoxville	1.29	0.84		6.2	23
Tex:	El Paso	2.10	1.03		2.7	16
Wash:	Spokane	1.33	1.10		6.1	28
Averages		1.80	1.18		7.7	25.8
January 1962						
Calif:	Los Angeles	2.01	1.45	25	4.0	32
D.C:	Washington	1.64	1.00	17	6.1	13
Ill:	Chicago	1.63	1.01	7	5.4	21
Mich:	Detroit	1.26	0.93	5	2.3	15
Averages		1.63	1.10	13.5	4.5	20.2
March 1962						
Colo:	Denver	1.60	0.86[a]	< 2	5.6	18
N.Y:	New York	1.53	1.12	< 2	8.3	14
Ohio:	Cincinnati	1.14	0.80	92	4.6	16
Pa:	Philadelphia	1.56	1.39	3	8.0	19
Averages		1.46	1.04	24.8	6.6	16.8
May 1962						
Calif:	San Francisco	1.59	1.05	38	8.1	33
Ga:	Atlanta	1.33	1.09	90	21.9	89
Mass:	Boston	2.33	1.40	< 2	11.2	23
Texas:	El Paso	1.87	1.42	15	3.6	13
Averages		1.78	1.25	36.2	11.2	39.5
June 1962						
Kans:	Wichita	2.26	1.33	86	15.8	72
Nev:	Las Vegas	1.78	0.85	12	4.1	25
S. Dak:	Sioux Falls	1.71	0.96	106	22.6	74
Wash:	Spokane	1.70	1.63	137	25.5	124
Averages		1.86	1.19	85.2	17.0	73.8

[a] The less-than values were used as the whole number in computing the strontium-90 averages.

In order to compare the calcium intake from milk with the calcium intake from the total diet of teen-agers, table 4 displays the ratio of the intake of calcium from milk to that from the diet. These ratios were calculated by dividing the daily calcium intake from milk by the daily calcium intake from the total diet. Table 5, derived in a similar fashion, shows the ratio of the intake of strontium-90 from milk to that from the total diet. Total diet samples, including milk, were analyzed. Milk samples were also analyzed. The ratio of the total diet values to milk values may therefore be greater than unity because of analytical errors. The average ratio of intake of calcium from milk to that from the total diet increased significantly in June 1962, when the average levels of strontium-90 were highest. Notably low values for strontium-90 in milk, as compared with those in the diet, were reported for Los Angeles.

For convenience, table 6 is arranged to show the relative contribution of milk to the total dietary intake using the results from the 10 cities in tables 4 and 5. The distribution of the ratios of calcium in milk to the ratios of calcium in the total diet have a sharply defined range. Twenty-four of 40 observations indicate that the calcium milk/diet ratio is between 0.60 and 0.69. The strontium-90 milk/diet ratios have a flatter distribution. However, 28 of 40 observations lie between 0.30 and 0.79.

TABLE 4.—RATIOS OF CALCIUM INTAKE FROM MILK RELATIVE TO CALCIUM INTAKE FROM THE TOTAL DIET, JANUARY-JUNE 1962

Sampling location		January	March	May	June
Calif:	Los Angeles	0.36	0.46	0.64	0.60
Colo:	Denver	0.73	0.57	0.58	0.64
Ill:	Chicago	0.64	0.60	0.61	0.62
La:	New Orleans	0.67	0.62	0.73	0.67
Mass:	Boston	0.60	0.64	0.50	0.49
N.Y:	New York	0.71	0.70	0.70	0.63
S. Dak:	Sioux Falls	0.63	0.50	0.64	0.65
Tenn:	Knoxville	0.55	0.69	0.58	0.65
Tex:	El Paso	0.60	0.61	0.60	0.68
Wash:	Spokane	0.56	0.63	0.62	0.90
Averages		0.61	0.60	0.62	0.65

TABLE 5.—RATIOS OF STRONTIUM-90 INTAKE FROM MILK RELATIVE TO STRONTIUM-90 INTAKE FROM THE TOTAL DIET, JANUARY-JUNE 1962

Sampling locations	January	March	May	June
Boston	0.35	0.30	0.30	0.39
Chicago	0.49	0.28	0.41	0.79
Denver	0.41	0.47	0.52	0.42
El Paso	0.43	0.34	0.27	0.24
Knoxville	0.45	0.66	0.57	0.87
Los Angeles	0.07	0.16	0.26	0.22
New Orleans	0.76	0.66	0.79	0.70
New York	0.55	0.43	0.36	0.80
Sioux Falls	0.62	0.36	0.59	0.93
Spokane	0.46	[a] 1.00	0.65	[a] 1.05
Averages	0.46	0.47	0.47	0.64

[a] Because of analytical error at low levels, values larger than 1 are possible.

TABLE 6.—COMPARISON OF STRONTIUM-90 IN MILK TO THAT IN THE TOTAL DIET AND COMPARISON OF CALCIUM IN MILK TO THAT IN THE TOTAL DIET[a]

Ratio range: milk/total diet	Strontium-90	Calcium
0.00-0.09	1	0
0.10-0.19	1	0
0.20-0.29	5	0
0.30-0.39	7	1
0.40-0.49	9	2
0.50-0.59	4	7
0.60-0.69	4	24
0.70-0.79	4	5
0.80-0.89	2	0
0.90-1.00	3	1

[a] Values are the number of observations in each milk to total diet ratio range.

Analysis and Discussion

The inclusion of dietary radionuclide intake data for May 1961 permits a limited evaluation of the effects of the resumption of nuclear testing in September 1961. For example, no strontium-89 was evident in the May 1961 sampling but it was clearly apparent in the January 1962 sampling, and rose in June 1962 to the highest 10-city average. The maximum reported intake value of 537 pc/day for strontium-89 in New Orleans in March 1962 is about one-fourth of the top of FRC Range II—200 pc/day.

Again, in the case of strontium-90, New Orleans was observed to have the highest of the 10-city average levels. The maximum observed intake value of 72.4 pc/day is about one-third of the top of FRC Range II—200 pc/day.

Of lesser magnitude, compared to existing standards, is the dietary intake of cesium-137. For analysis, it may be assumed that the maximum permissible concentration (MPC) of cesium-137 for the general population is 0.01 times the occupational MPC set by the International Committee on Radiation Protection, and that the occupational MPC for cesium-137 in water for continuous exposure is 200 pc/cc (*9*). Additionally, it may be assumed that man consumes 2.2 liters of water a day. Hence, the maximum permissible daily intake of cesium-137 is estimated to be about 4,400 pc/day. This is considerably in excess of the highest observed intake for cesium-37 of 325 pc/day.

The maximum observed dietary intake average value for radium-226 of 5.1 pc/day in May 1962 is about one-fourth of the top of FRC Range II for this naturally occurring radionuclide.

Another naturally occurring isotope that exposes the body to radiation is potassium-40. This isotope delivers a dose-rate to gonadal tissue of about 17 and 2 mrem per year from beta- and gamma-radiation, respectively. This may be compared to the guidance value the FRC has established—500 mrem/year for the exposure of individuals in the population to all sources of radiation.

Table 6 shows the relationship of strontium-90 in milk to strontium-90 in the total diet. The widespread distribution of strontium-90 in milk as compared to strontium-90 in diet gives some indication that only a relative idea of the strontium-90 intake from the diet can be obtained from observing the strontium-90 intake from milk.

The relationships of the calcium in milk and calcium in diet distributions shown in Table 6 are of interest. The well-defined distribution of calcium in milk as compared to calcium in diet gives some indication that only a relative idea of the strontium intake from the diet can be obtained from observing the strontium intake from milk.

Summary

Strontium-89 was not detectable in the May 1961 teen-age diet sampling, but levels between 51.5 and 90.6 were found in the first half of 1962. Similar trends were noted for strontium-90 and cesium-137, with the greatest increases observed in June 1962.

The infant diet sampling showed increases in strontium-89, strontium-90, and cesium-137 similar to those in the teen-age diet for the same sampling period.

The daily intake values observed for strontinum-89, strontium-90, and radium-226 intakes fall in FRC Range II.

REFERENCES

(*1*) Consumers' Union: Strontium-90 in the Total Diet, *Consumer Reports, 25*:282-93 (June 1960).
(*2*) Consumers' Union: A Follow-up Study on Strontium-90 in the Total Diet, *Consumer Reports, 26*: 547-9 (October 1961).
(*3*) Consumers' Union: Fallout and the U. S. Diet, *Consumer Reports, 27*:139-43 (March 1962).
(*4*) Consumers' Union: Fallout in Foods: Preliminary Data, Teen-Age Diets, *Consumer Reports, 27*: 399 (August 1962).
(*5*) Consumers' Union: Fallout in our Food, *Consumer Reports, 28*:190-3 (April 1963).
(*6*) The National Academy of Sciences—National Research Council: *Recommended Dietary Allowances*, National Research Council Publication 589, Revised (1958).
(*7*) Yalman, and Boulgerman: *Analytical Chemistry, 31*:1230 (1959).
(*8*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (September 1961), price 20 cents.
(*9*) United Nations General Assembly: *Report of the United Nations Scientific Committee on the Effects of Atomic Radiation*, United Nations (1962).

Correction for June 1963 issue:

Radiological Health Data regrets the error appearing in table 1 on page 286 of the June issue. The date shown in the second title box should be May 1962 instead of May 1963.

SECTION III.–MILK

Milk Surveillance

Milk is the single food item often used as an indicator of the population's intake of radionuclides from the environment, although it is only one of the many sources of dietary intake of radionuclides. A number of factors account for its use as an indicator food. For example, milk is consumed by a large proportion of the U. S. population. It is produced on a regular basis throughout the country, and it is more easily sampled and analyzed than most other foods. Further, when properly composited from individual milk processing plants, milk samples are representative of the milk consumed in a marketing area.

PASTEURIZED MILK NETWORK
March 1963

Division of Radiological Health and
Division of Environmental Engineering and Food Protection,
Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a 12-station raw milk monitoring network, which was established by the Service in 1957. One of the primary objectives of this early network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a 46-station pasteurized milk sampling program in July 1960. The 46 stations were selected to provide general nationwide coverage of milk production and consumption areas.

As further needs developed, more milk sampling points were added, through July 1962, when the total number of stations reached was 62. Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. After collection, the composites are preserved with formaldehyde and are sent to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analyses. Approximately 3-6 days after sample collection, any results from gamma analyses of iodine-131 which indicate concentrations of this radionuclide greater than 100 pc/liter are made available to State public health officials and the Federal Radiation Council for possible public health action. Complete analytical results are available six to seven weeks after sample collection and publication in *Radiological Health Data* follows 3 to 4 months after sample collection because of the time required for shipment, processing, analysis of radiostrontium, data compilation and publication procedures.

Sampling and Compositing Procedures

The method of compositing specifies that each station's sample be composited of subsamples from each milk processing plant in

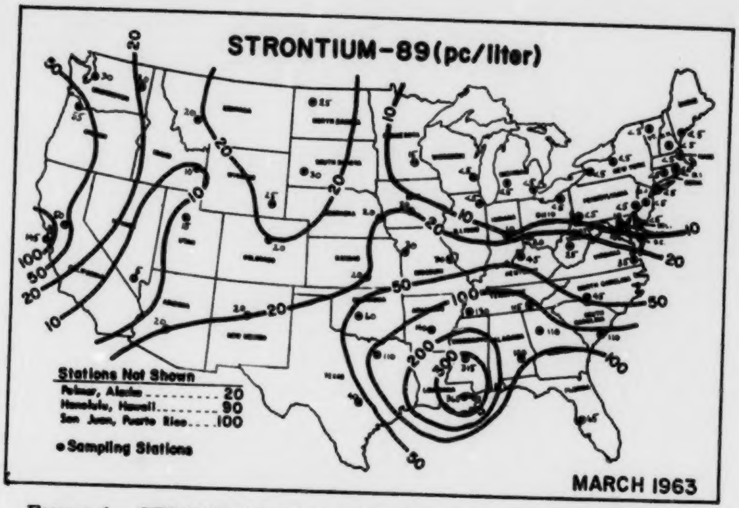
STRONTIUM-89(pc/liter)
Stations Not Shown
Palmer, Alaska 20
Honolulu, Hawaii 90
San Juan, Puerto Rico 100
• Sampling Stations
MARCH 1963

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK

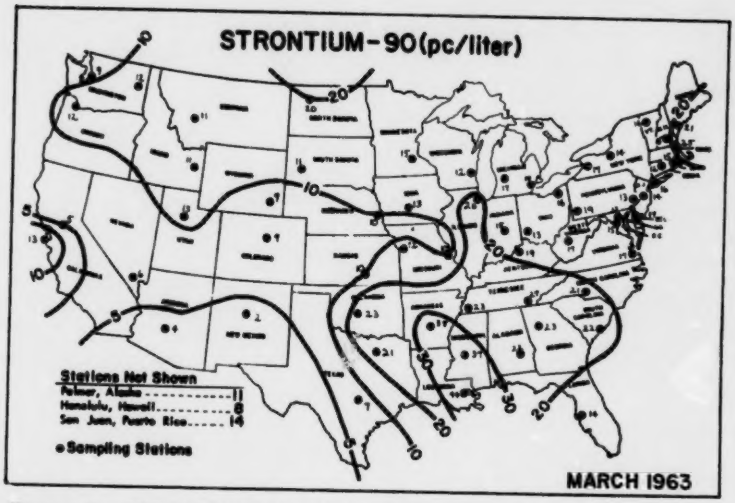
STRONTIUM-90(pc/liter)
Stations Not Shown
Palmer, Alaska 11
Honolulu, Hawaii 8
San Juan, Puerto Rico 14
• Sampling Stations
MARCH 1963

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

proportion to the plant's sales in the community served. At most of the stations, the composited sample represents 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in September 1961 and continuing through 1963, sampling was done twice a week at most stations, or daily for short periods at selected stations. Since then, sampling at most stations has been reduced to once a week.

All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention. Further atmospheric nuclear testing may require reevaluation and adjustment of the sampling frequency and schedule of analyses.

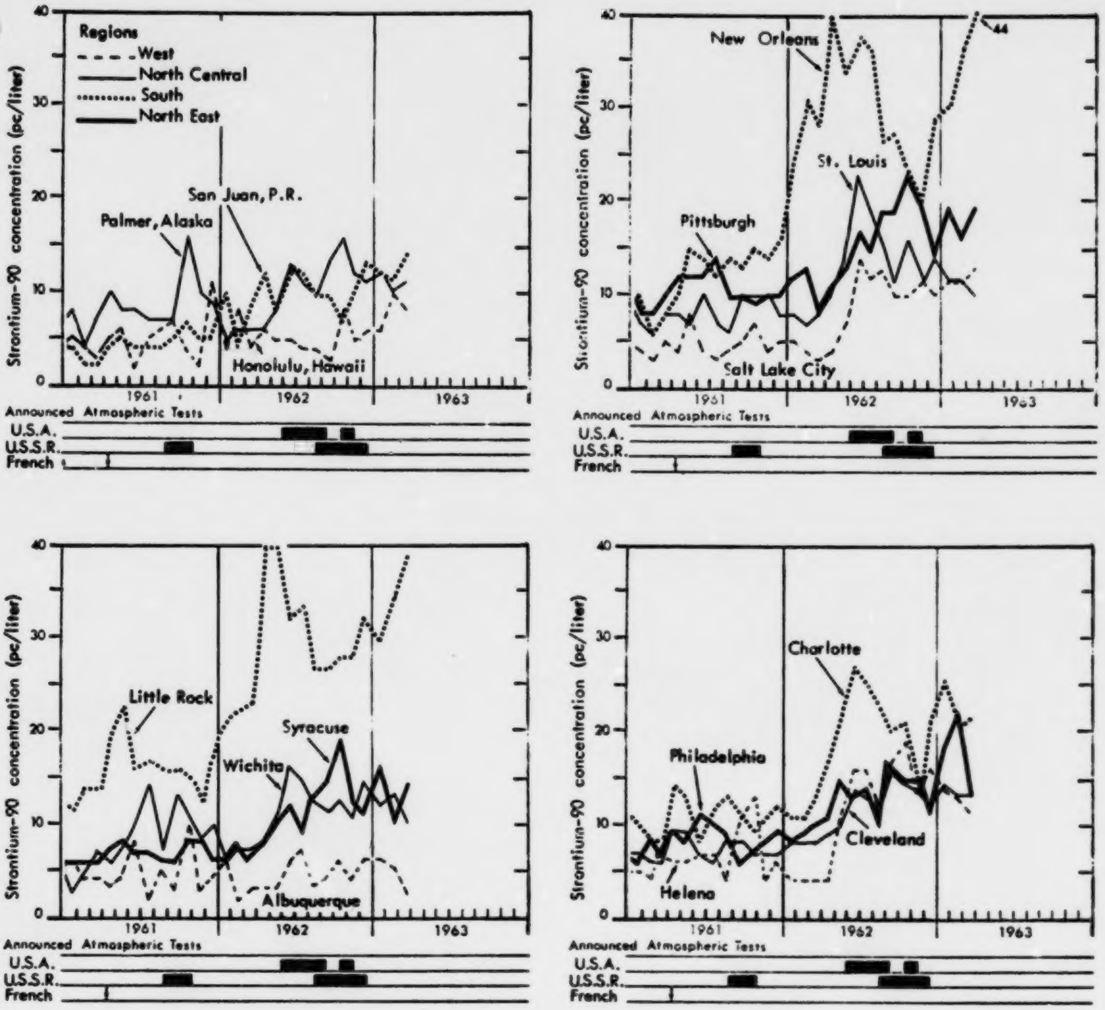

FIGURE 3.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

Analytical Errors

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy,[1] while strontium-90 concentrations are determined by radiochemical procedures. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation is relatively high. The variation is dependent upon the method of chemical analysis, the counting rate and counting time, the interferences from other radionuclides, and the background counting rate. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 minutes for low background beta determinations are used. Table 1 shows the approximate total laboratory analytical error associated with different radionuclide concentrations in milk. The $\pm 2\sigma$ range about the measured concentra-

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH TYPICAL CONCENTRATIONS OF SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error, ± 2σ (percent of concentration)	Estimated concentration (pc/liter)	Error, ± 2σ (percent of concentration)	Estimated concentration (pc/liter)	Error, ± 2σ (percent of concentration)
Iodine-131	10	± 100%	20	± 50%	100	± 10%
Barium-140	10	± 100%	20	± 50%	100	± 10%
Cesium-137	5	± 100%	10	± 50%	100	± 10%
Strontium-89	5	± 100%	10	± 50%	100	± 10%
Strontium-90	1	± 100%	2	± 50%	20	± 10%

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, MARCH 1963

(Average radioactivity concentrations in pc/liter)

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month
Ala:	Montgomery	1.26	1.24	85	100	18	22	< 10	< 10	50	55	10	20
Alaska:	Palmer	1.19	1.14	20	20	11	11	10	< 10	65	50	10	< 10
Ariz:	Phoenix	1.20	1.12	20	20	4	4	< 10	< 10	20	20	< 10	< 10
Ark:	Little Rock	1.23	1.22	125	140	34	38	20	10	90	105	20	20
Calif:	Sacramento	1.23	1.19	25	50	4	5	10	< 10	80	85	10	< 10
	San Francisco	1.26	1.20	85	145	8	13	10	< 10	85	50	10	10
Colo:	Denver	1.29	1.26	15	20	11	9	20	20	65	55	< 10	< 10
Conn:	Hartford	1.11	1.12	< 5	< 5	12	12	< 10	< 10	65	60	< 10	< 10
Del:	Wilmington	1.13	1.14	5	< 5	17	17	< 10	< 10	70	70	< 10	< 10
D. C:	Washington	1.22	1.21	10	10	15	15	< 10	< 10	60	60	< 10	< 10
Fla:	Tampa	1.24	1.22	50	65	14	14	20	< 10	135	165	< 10	10
Ga:	Atlanta	1.24	1.22	100	110	21	23	10	< 10	85	90	20	20
Hawaii:	Honolulu	1.14	1.07	55	90	8	8	20	< 10	55	55	10	< 10
Idaho:	Idaho Falls	1.25	1.18	10	10	11	11	10	< 10	75	75	< 10	< 10
Ill:	Chicago	1.18	1.15	< 5	< 5	16	20	< 10	< 10	70	70	< 10	< 10
Ind:	Indianapolis	1.16	1.19	10	10	16	15	< 10	< 10	60	60	< 10	< 10
Iowa:	Des Moines	1.23	1.19	15	20	14	13	10	< 10	65	60	10	< 10
Kans:	Wichita	1.25	1.20	20	20	12	10	10	< 10	50	45	10	< 10
Ky:	Louisville	1.22	1.21	35	45	20	19	< 10	< 10	55	50	< 10	< 10
La:	New Orleans	1.27	1.25	265	365	37	44	20	10	120	155	30	40
Maine:	Portland	1.14	1.20	< 5	< 5	20	21	< 10	< 10	105	105	< 10	< 10
Md:	Baltimore	1.23	1.22	5	10	14	12	< 10	< 10	65	70	< 10	< 10
Mass:	Boston	1.14	1.16	< 5	< 5	19	25	< 10	< 10	95	95	< 10	< 10
Mich:	Detroit	1.16	1.17	< 5	< 5	18	19	< 10	< 10	75	75	< 10	< 10
	Grand Rapids	1.16	1.18	5	< 5	15	17	10	10	75	75	< 10	< 10
Minn:	Minneapolis	1.20	1.16	15	15	17	15	10	< 10	110	105	10	< 10
Miss:	Jackson	1.33	1.31	230	315	32	37	20	10	80	105	80	40
Mo:	Kansas City	1.12	1.19	25	30	14	12	< 10	< 10	50	45	10	< 15
	St. Louis	1.24	1.21	20	30	11	10	10	< 10	60	50	20	< 10
Mont:	Helena	1.18	1.04	20	20	13	11	10	< 10	90	80	25	< 10
Nebr:	Omaha	1.26	1.16	20	20	14	10	10	< 10	65	50	10	< 10
Nev:	Las Vegas	1.18	1.11	10	5	6	6	< 10	10	45	40	10	< 10
N.H:	Manchester	1.16	1.19	< 5	< 5	18	15	10	< 10	110	110	< 10	< 10
N.J:	Trenton	1.14	1.15	< 5	< 5	13	14	< 10	< 10	65	65	< 10	< 10
N.Mex:	Albuquerque	1.23	1.19	15	20	4	2	< 10	< 10	80	45	10	< 10
N.Y:	Buffalo	1.11	1.11	5	< 5	16	17	< 10	< 10	85	65	< 10	< 10
	New York	1.12	1.17	< 5	< 5	16	16	< 10	< 10	65	60	< 10	< 10
	Syracuse	1.12	1.17	< 5	< 5	13	14	< 10	< 10	65	65	< 10	< 10
N.C:	Charlotte	1.27	1.26	30	45	22	21	< 10	< 10	60	65	< 10	< 10
N.Dak:	Minot	1.21	1.19	15	25	23	20	< 10	10	55	80	20	< 10
Ohio:	Cincinnati	1.11	1.13	15	20	17	16	< 10	< 10	55	65	< 10	< 10
	Cleveland	1.12	1.09	< 5	< 5	14	13	< 10	< 10	60	65	< 10	< 10
Okla:	Oklahoma City	1.23	1.20	60	60	20	23	20	< 10	55	60	10	10
Ore:	Portland	1.25	1.22	55	55	11	12	< 10	< 10	70	65	20	< 10
Pa:	Philadelphia	1.13	1.17	5	< 5	18	13	< 10	< 10	65	80	< 10	< 10
	Pittsburgh	1.13	1.16	5	< 5	18	19	< 10	< 10	80	75	< 10	< 10
P.R:	San Juan	1.20	1.18	135	100	12	14	20	10	65	70	20	10
R.I:	Providence	1.18	1.16	5	< 5	16	15	< 10	< 10	75	80	< 10	< 10
S.C:	Charleston	1.26	1.24	105	110	23	22	20	10	80	90	20	20
S.Dak:	Rapid City	1.00	0.93	25	80	13	11	10	< 10	90	70	< 10	< 10
Tenn:	Chattanooga	1.29	1.25	75	115	23	27	< 10	< 10	65	75	10	20
	Memphis	1.26	1.22	100	130	23	23	10	< 10	50	60	20	20
Tex:	Austin	1.22	1.18	50	40	8	7	10	< 10	30	30	< 10	< 10
	Dallas	1.25	1.22	110	110	20	21	20	< 10	60	65	20	20
Utah:	Salt Lake City	1.26	1.21	15	15	12	13	10	10	100	90	10	< 10
Vt:	Burlington	1.11	1.10	< 5	< 5	16	16	< 10	< 10	85	80	< 10	< 10
Va:	Norfolk	1.25	1.23	30	35	17	17	< 10	< 10	65	65	< 10	< 10
Wash:	Seattle	1.24	1.19	30	30	10	9	10	< 10	75	60	10	< 10
	Spokane	1.21	1.25	15	20	12	12	10	< 10	85	70	10	< 10
W.Va:	Charleston	1.23	1.20	15	25	19	17	< 10	< 10	50	50	< 10	< 10
Wis:	Milwaukee	1.14	1.18	10	< 5	11	12	< 10	< 10	65	70	< 10	< 10
Wyo:	Laramie	1.24	1.20	20	25	12	9	< 10	< 10	95	80	20	< 10
Network average		1.20	1.18	37	44	15.6	15.8	< 10	< 10	70	70	< 10	< 10

tion corresponds to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined as that concentration at which the 2σ analytical error is 100 percent. Therefore, the minimum detectable concentration in units of pc/liter are Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Data Presentation

Table 2 presents summaries of all available analyses for March 1963, (February 24-March 30, 1963. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average. Although no data are presented on the stable potassiuum concentrations in milk, analysis has indicated that the usual range of concentrations is from 1.4 to 1.7 grams/liter.

Figures 1 and 2 are isoconcentration maps showing the estimated radionuclide concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station.

Selected Monthly Strontium-90 Profiles

Continuing the practice followed in previous issues of RHD, figure 3 presents the average monthly strontium-90 concentrations in pasteurized milk from 16 additional cities in the sampling program. Each individual graph shows the strontium-90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions.

INDIANA MILK NETWORK
April 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analyses in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 4).

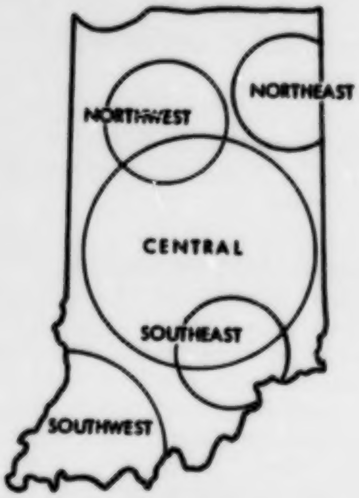

FIGURE 4.—INDIANA MILK SAMPLING LOCATIONS

The milk samples are routinely analyzed for iodine-131, cesium-137, barium-lanthanum-140, strontium-89, and strontium-90. Analyses for the gamma emitters iodine-131, cesium-137, and barium-lanthanum-140 are conducted on a weekly basis except when iodine-131 results exceed 100 pc/liter, at which time the frequency of sampling is increased. Strontium-89 and strontium-90 analyses are performed monthly on samples which are composited from weekly aliquots.

The ion exchange analytical procedure (*1*) is used for strontium-89 and strontium-90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodine crystal are used for the gamma analysis of iodine-131, cesium-137 and barium-lanthanum-140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 3. The average is an arithmetic average of the station values.

TABLE 3.—RADIONUCLIDES IN INDIANA MILK, APRIL 1963
[Concentrations in pc/day]

Milkshed	Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
Southwest	30	26	< 10	50	< 10
Northeast	< 10	17	< 10	65	< 10
Central	10	24	< 10	60	< 10
Northwest	35	19	< 10	70	< 10
Northeast	95	29	< 10	60	< 10
State average	35	23	< 10	60	< 10

REFERENCE

(*1*) Porter C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determinations of strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry 33*:1306-8 (September 1961).

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CANADIAN MILK NETWORK[1]
February 1963

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

In January 1963, the Canadian Department of National Health and Welfare substituted the radioanalysis of fresh liquid milk for the analysis of powdered milk. The Department had analyzed milk powders from November 1955 through December 1962, but liquid whole milk had been monitored since April 1962 for iodine-131 only.

With this change, it has been possible to choose milk sampling locations in the same areas as the air and precipitation stations. This permits the observation of a number of environmental variables which may affect the radionuclide levels in milk. In addition, it is now possible to report radionuclide concentrations in terms of the activity per liter of milk as well as per gram of calcium in milk.

A detailed discussion of the sampling and radiochemical procedures employed for milk analyses may be found in the Department's publications (*1, 2*). Table 4 presents the results of the measurements of strontium-89, strontium-90, cesium-137, and iodine-131 in Canadian liquid whole milk for February.

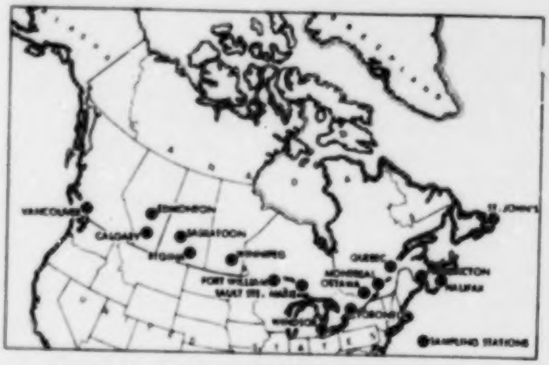

FIGURE 5.—CANADIAN MILK SAMPLING STATIONS, FEBRUARY 1963

It shoud be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the concentration levels in a particular medium with the so-called Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (3), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average

TABLE 4.—RADIONUCLIDES IN CANADIAN WHOLE MILK, FEBRUARY 1963

Station	Calcium (g/liter)	Strontium-89 (pc/liter)	Strontium-90 (pc/liter)	Iodine-131 (pc/liter)[a]	Cesium-137 (pc/liter)
Calgary	1.29	12	20.8	3	77
Edmonton	1.17	10	18.2	[b]—	63
Fort William	1.37	6	25.2	—	76
Fredericton	1.19	0	31.1	—	132
Halifax	1.25	5	27.0	1	59
Montreal	1.09	10	16.5	—	54
Ottawa	1.19	0	18.7	4	59
Quebec	1.17	0	23.9	4	97
Regina	1.19	3	16.1	—	26
Saint John's	1.19	6	20.9	—	70
Saskatoon	1.28	9	16.2	3	20
Sault Ste. Marie	1.23	0	14.0	1	43
Toronto	1.44	2	7.3	—	57
Vancouver	1.12	2	19.9	3	86
Windsor	1.32	0	12.3	6	32
Winnipeg	1.35	9	17.1	2	48
Average	1.25	5	19.1	3	63

[a] Each of the iodine-131 values is the average of nine samples.
[b] A dash indicates no sample.

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[1] Data from *Data from Radiation Protection Programs*, Radiation Protection Division, Canadian Department of National Health and Welfare.

levels over an extended period, such as one year, represent a better basis for comparison than do individual levels at any specific time.

REFERENCES

(1) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurements of Radioactive Strontium in Canadian Milk Powder Samples, CNHW-RP-1*, (July 1958).

(2) Mar, Peter G.: *Outline of Procedure for the Rariochemical Analysis of Dried Milk Powders for Strontium and Yttrium, RPD-5*, Radiation Protection Division, Department of National Health and Welfare (June 1, 1960).

(3) Recommendation of the International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

Twelve-Month Sum of Daily Radionuclide Content of One Liter of Pasteurized Milk

Iodine-131: May 1962—April 1963
Strontium-89 and Strontium-90: April 1962— March 1963

Division of Radiological Health,
Public Health Service

The guidance of the Federal Radiation Council (FRC) is given in terms of transient rates of intake of radioactive materials in micromicrocuries (or picocuries) per day. The action ranges proposed in FRC Report No. 2 are based on radiation doses considered acceptable for lifetime exposure from normal peacetime atomic industry operations (*1*). The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures and emphasizes that the annual acceptable exposure dose is not a "danger point" which, if exceeded, requires protective measures (*1, 2, 3,*).

To facilitate comparison of the concentrations of certain radionuclides in milk with the Radiation Protection Guides, tables 1 and 2 furnish estimates of the contribution of milk to the total dietary intake of iodine-131, strontium 89, and strontium-90. The tables are developed from the PHS Pasteurized Milk Network monthly averages of the radionuclides. The index values are estimated sums of the daily amounts of a radionuclide in one liter of milk for a 12-month period.

The tables show 12-month index values for each of the Network's 62 sampling locations. Due to the longer time required for strontium-89 and strontium-90 analyses, these 12-month index values are for the year beginning one month earlier than the iodine-131 values. The columns of monthly index values in each table are used to compute the net change as the yearly index values are advanced by one month. The following column shows this new 12-month index value. In addition, the second column in table 1 gives the iodine-131 April 1963 concentration averages.

The data in tables 1 and 2 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly averages for all weeks ending within a given month are averaged to obtain an average value for the month, and (c) the monthly radionuclide index value is determined by multiplying the monthly average by the number of days in the month. This number will be either 28 or 35, corresponding to the number of complete calendar weeks ending in a given month. Procedures exemplified by a and b above tend to minimize the effect of any one day's sample results on the average for the month, particularly for a short-lived radionuclide such as iodine-131. The yearly index values are obtained by the following procedure. Column (A) lists the twelve-month index values for the period indicated. Columns B and C, show the monthly index values for the periods indicated. The values in column (D) are obtained by adding the values in column (C) to those in column (A) and subtracting those in (B).

For a number of reasons it is desirable to use a standard quantity of milk in the develop-

TABLE 1.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

(pc day/liter)

Station location		Apr. 1963 iodine-131 averages (pc/liter)	Iodine-131 index values [a]			
			Apr. 1962-Mar. 1963 (A)	Apr. 1962 (B)	Mar. 31, 1963-Apr. 27, 1963 (C)	May 1962-Apr. 1963 (D)
Ala:	Montgomery	< 10	6,590	140	140	6,590
Alaska:	Palmer	< 10	38,050	140	140	38,050
Ariz:	Phoenix	< 10	4,100	140	140	4,100
Ark:	Little Rock	< 10	14,840	140	140	14,840
Calif:	Sacramento	< 10	5,050	140	140	5,050
	San Francisco	< 10	4,770	280	140	4,630
Colo:	Denver	< 10	6,240	140	140	6,240
Conn.	Hartford	< 10	7,670	140	140	7,670
Del:	Wilmington	< 10	11,870	140	140	11,870
D. C:	Washington	< 10	8,440	140	140	8,440
Fla:	Tampa	< 10	6,660	140	140	6,660
Ga:	Atlanta	< 10	9,040	140	140	9,040
Hawaii:	Honolulu	< 10	4,730	140	140	4,730
Idaho:	Idaho Falls	< 10	9,070	140	140	9,070
Ill:	Chicago	< 10	13,690	140	140	13,690
Ind:	Indianapolis	< 10	12,010	140	140	12,010
Iowa:	Des Moines	< 10	21,670	140	140	21,670
Kans:	Wichita	< 10	21,740	140	140	21,740
Ky:	Louisville	< 10	10,540	140	140	10,540
La:	New Orleans	20	9,770	140	560	10,190
Maine:	Portland	< 10	8,160	140	140	8,160
Md:	Baltimore	< 10	8,690	140	140	8,690
Mass:	Boston	< 10	7,950	140	140	7,950
Mich:	Detroit	< 10	12,820	140	140	12,820
	Grand Rapids	< 10	9,730	140	140	9,730
Minn:	Minneapolis	< 10	15,650	140	140	15,650
Miss:	Jackson	< 10	9,700	140	140	9,700
Mo:	Kansas City	< 10	30,070	140	140	30,070
	St. Louis	< 10	12,360	140	140	12,360
Mont:	Helena	< 10	14,110	140	140	14,110
Nebr:	Omaha	< 10	19,220	140	140	19,220
Nev:	Las Vegas [b]	< 10	4,590	[c] —	140	4,730
N.H:	Manchester	< 10	7,710	140	140	7,710
N.J:	Trenton	< 10	7,990	140	140	7,990
N.Mex:	Albuquerque	< 10	6,520	280	140	6,380
N.Y:	Buffalo	< 10	8,720	140	140	8,720
	New York	< 10	11,660	140	140	11,660
	Syracuse	< 10	10,150	140	140	10,150
N.C:	Charlotte	< 10	3,370	140	140	3,370
N.Dak:	Minot	< 10	14,910	140	140	14,910
Ohio:	Cincinnati	< 10	14,600	140	140	14,600
	Cleveland	< 10	11,100	140	140	11,100
Okla:	Oklahoma City	< 10	18,380	140	140	18,380
Ore:	Portland	< 10	9,770	140	140	9,770
Pa:	Philadelphia	< 10	10,820	140	140	10,820
	Pittsburgh	< 10	14,810	140	140	14,810
P.R:	San Juan [d]	< 10	6,130	140	140	6,130
	Providence	< 10	8,580	140	140	8,580
S.C:	Charleston	< 10	7,180	140	140	7,180
S.Dak:	Rapid City	< 10	14,150	140	140	14,150
Tenn:	Chattanooga	< 10	7,850	140	140	7,850
	Memphis	< 20	10,050	140	140	10,050
Tex:	Austin	< 10	11,040	140	140	11,040
	Dallas	10	18,840	140	280	18,980
Utah:	Salt Lake City	< 10	31,920	140	140	31,920
Vt:	Burlington	< 10	8,380	140	140	8,380
Va:	Norfolk	< 10	6,410	140	140	6,410
Wash:	Seattle	< 10	9,770	140	140	9,770
	Spokane	< 10	21,390	140	140	21,390
W.Va.	Charleston	< 10	6,970	140	140	6,970
Wis:	Milwaukee	< 10	14,460	140	140	14,460
Wyo:	Laramie	< 10	19,540	140	140	19,540

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual iodine-131 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month I^{131} index × milk consumption factor = 12-month I^{131} intake
(pc day/liter) (liter/day/person) (pc/person)

[b] Station included in milk network in July 1962. The sums in columns A and D are therefore for 9 and 10 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received in November 1962. The sums in columns A and D are therefore for 11 months.

TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-89 AND STRONTIUM-90 IN ONE LITER OF MILK[a]

[pc day/liter]

Station location		Strontium-89 index values				Strontium-90 index values			
		Mar. 1962-Feb. 1963 (A)	Mar. 1962 (B)	Feb. 24, 1963-Mar. 30, 1963 (C)	Apr. 1962-Mar. 1963 (D)	Mar. 1962-Feb. 1963 (A)	Mar. 1962 (B)	Feb. 24, 1963-Mar. 30, 1963 (C)	Apr. 1962-Mar. 1963 (D)
Ala:	Montgomery	24,255	3,850	3,500	23,905	5,586	490	770	5,866
Alaska:	Palmer	19,375	90	700	19,985	3,920	210	385	4,095
Ariz:	Phoenix	6,600	875	700	6,425	1,176	105	140	1,211
Ark:	Little Rock	50,365	5,600	4,900	49,665	11,242	805	1,330	11,767
Calif:	Sacramento	7,195	1,225	1,750	7,720	1,421	140	175	1,456
	San Francisco	13,720	3,150	5,075	15,645	2,037	280	455	2,212
Colo:	Denver	10,310	90	700	10,920	3,899	175	315	4,039
Conn:	Hartford	8,140	90	90	8,140	3,988	245	420	4,163
Del:	Wilmington	13,195	350	90	12,935	5,173	315	595	5,453
D. C:	Washington	12,760	90	350	13,020	5,537	245	525	5,817
Fla:	Tampa	10,115	700	2,275	11,690	3,801	210	490	4,081
Ga:	Atlanta	29,680	4,550	3,850	28,980	6,804	490	805	7,119
Hawaii:	Honolulu	8,785	1,050	3,150	10,885	1,974	140	280	2,114
Idaho:	Idaho Falls	9,015	90	350	9,275	3,626	140	385	3,871
Ill:	Chicago	10,800	90	90	10,800	4,368	175	700	4,893
Ind:	Indianapolis	14,140	700	350	13,790	5,173	280	525	5,418
Iowa:	Des Moines	24,100	90	700	24,710	4,970	175	455	5,250
Kans:	Wichita	18,620	1,050	700	18,270	4,438	245	350	4,543
Ky:	Louisville	28,490	1,225	1,575	28,840	7,518	315	665	7,868
La:	New Orleans	55,510	11,025	12,775	57,260	11,186	980	1,540	11,746
Maine:	Portland	10,800	90	90	10,800	5,467	350	735	5,852
Md:	Baltimore	11,745	90	350	12,005	5,684	280	420	5,824
Mass:	Boston	11,430	90	90	11,430	6,132	350	875	6,657
Mich:	Detroit	9,855	90	90	9,855	4,578	210	665	5,033
	Grand Rapids	8,560	90	90	8,560	3,934	280	595	4,249
Minn:	Minneapolis	20,425	90	525	20,860	6,496	210	525	6,811
Miss:	Jackson	52,500	7,700	11,025	55,825	9,156	875	1,295	9,576
Mo:	Kansas City	31,080	700	1,050	31,430	5,600	245	420	5,775
	St. Louis	19,390	350	1,050	20,090	5,103	280	350	5,173
Mont:	Helena	16,870	175	700	17,395	4,739	140	385	4,984
Nebr:	Omaha	21,035	175	700	21,560	5,197	175	350	5,372
Nev:	Las Vegas[b]	5,600	[c] —	175	5,775	1,302	—	210	1,512
N.H:	Manchester	10,415	90	90	10,415	5,614	350	525	5,789
N.J:	Trenton	9,995	90	90	9,995	4,186	280	490	4,396
N. Mex:	Albuquerque	6,185	90	700	6,795	1,701	105	70	1,666
N.Y:	Buffalo	8,980	90	90	8,980	4,508	245	595	4,858
	New York	10,555	90	90	10,555	5,271	280	560	5,551
	Syracuse	9,625	175	90	9,540	4,284	210	490	4,564
N.C:	Charlotte	20,510	1,225	1,575	20,860	7,511	455	735	7,791
N. Dak:	Minot	16,865	90	875	17,650	7,686	280	700	8,106
Ohio:	Cincinnati	17,500	875	700	17,325	5,621	350	560	5,831
	Cleveland	10,730	90	90	10,730	4,606	280	455	4,781
Okla:	Oklahoma City	26,460	1,400	2,100	27,160	6,482	280	805	7,007
Ore:	Portland	31,045	700	1,925	32,270	5,082	245	420	5,257
Pa:	Philadelphia	10,415	90	90	10,415	5,145	350	455	5,250
	Pittsburgh	12,425	175	90	12,340	5,838	280	665	6,223
P.R:	San Juan[d]	26,005	3,150	3,500	26,355	3,591	315	490	3,766
R.I:	Providence	9,190	90	90	9,190	4,921	315	525	5,131
S.C:	Charleston	26,320	3,325	3,850	26,845	7,378	525	770	7,623
S. Dak:	Rapid City	20,355	90	1,050	21,315	5,908	210	385	6,083
Tenn:	Chattanooga	41,930	6,650	4,025	39,305	8,337	700	945	8,582
	Memphis	36,470	4,375	4,550	36,645	8,106	560	805	8,351
Tex:	Austin	11,935	1,050	1,400	12,285	2,814	245	245	2,814
	Dallas	31,255	2,800	3,850	32,305	5,817	350	735	6,202
Utah:	Salt Lake City	11,570	90	525	12,005	3,591	105	455	3,941
Vt:	Burlington	11,045	90	90	11,045	4,494	210	560	4,844
Va:	Norfolk	18,095	1,400	1,225	17,920	6,664	350	595	6,909
Wash:	Seattle	22,365	350	1,050	23,065	5,635	210	315	5,740
	Spokane	13,670	90	700	14,280	4,823	210	420	5,033
W. Va:	Charleston	21,070	350	875	21,595	7,133	280	595	7,448
Wis:	Milwaukee	8,665	90	90	8,665	3,304	175	420	3,549
Wyo:	Laramie	19,655	90	875	20,440	4,088	140	315	4,263

[a] The data in this table are index values not to be interpreted as consumption or total intake values. Annual strontium-89 or strontium-90 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average daily milk consumption for any selected group under consideration.

Example: 12-month index value (pc/liter) × milk consumption factor (liter /day/person) = 12-month intake (pc/person)

[b] Station included in milk network in July 1962. The sums in columns A and D are therefore for 8 and 9 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received for November 1962. The sums in columns A and D are therefore for 11 months.

ment of index values for the radionuclides. When one is concerned with strontium, 1 liter is a suitable quantity, as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the intake guidance for strontium. When one is concerned with iodine-131, the critical age group is the young infant. Available information suggests that the average milk consumption of infants in the 6-18 month group is not more than 1 liter per day. Thus, the index value based on 1 liter of milk, though not directly an average intake value, is probably the most useful index for estimating total intake.

REFERENCES

(1) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U. S. Government Printing Office (September 1961), price 20 cents.

(2) Chadwick, Donald R., and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data, 3*:159-65, Superintendent of Documents, Government Printing Office, Washington 25, D. C. (May 1962).

(3) Public Health Service: Special Report, *Radiological Health Data, 3*:ii-iii, Superintendent of Documents, Government Printing Office, Washington 25, D. C. (September 1962).

SECTION IV.–WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
January 1963

Division of Water Supply and Pollution Control, Public Health Service

Radioactivity levels in the surface waters of the United States have been included in the surveillance by the Public Health Service's National Water Quality Network since this nationwide sampling program was initiated in 1957. Beginning with the establishment of 50 sampling points, this network has been expanded as of May 1, 1963, to 126 stations (figure 1), which are operated jointly with State, Federal and local agencies and industry. The stations are located on the major waterways used for public water supplies, propagation of fish and wildlife, and recreational, agricultural, and industrial purposes. At these stations,

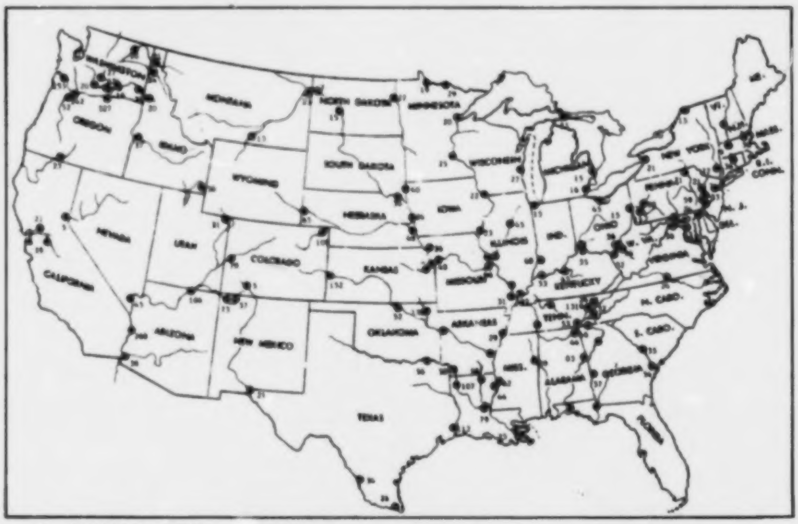
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
WISCONSIN
NEW YORK
ME.
VT.
MASS.
CONN.
N. J.
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
ILLINOIS
IND.
OHIO
VIRGINIA
KENTUCKY
CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TENN.
N. CARO.
S. CARO.
MISS.
ALABAMA
GEORGIA
TEXAS
FLORIDA

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, JANUARY 1963

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS [a]

[Average concentrations in pc/liter]

Station	January 1963			
	Beta activity		Alpha activity	
	Dissolved	Total	Dissolved	Total
Allegheny River: Pittsburgh, Pa.	21	30	0	0
Animas River: Cedar Hill, N. Mex.	30	37	8	9
Apalachicola River:				
Chattahoochie, Fla.	[b] —	—	—	—
Arkansas River				
Coolidge, Kans.	142	152	53	56
Ponca City, Okla.	32	52	12	13
Bear River: Preston, Idaho	25	30	2	2
Bighorn River: Hardin, Mont.	12	13	7	8
Big Sioux River				
Sioux Falls, S. Dak.	21	40	5	5
Chattahoochie River				
Atlanta, Ga.	—	—	—	—
Columbus, Ga.	15	37	0	0
Lanett, Ala.	22	83	0	7
Chena Slough: Fairbanks, Alaska	—	—	—	—
Clear Water River: Lewiston, Idaho	13	20	0	0
Clinch River				
Clinton, Tenn.	12	24	0	0
Kingston, Tenn.	1211	1316	1	2
Colorado River				
Loma, Colo.	34	78	13	20
Page, Ariz.	50	106	12	22
Boulder, City, Nev.	33	45	8	8
Parker Dam, Calif.-Ariz.	186	268	13	13
Yuma, Ariz.	26	38	13	13
Columbia River				
Northport, Wash.	13	20	1	1
Wenatchee, Wash.	23	27	0	0
Pasco, Wash.	473	524	1	1
McNary Dam, Ore.	294	822	1	1
Bonneville, Ore.	221	242	0	0
Clatskanie, Ore.	227	253	1	1
Connecticut River				
Wilder, Vt.	—	—	—	—
Northfield, Mass.	9	9	0	0
Enfield Dam, Conn.	23	36	< 1	< 1
Cuyahoga River: Cleveland, Ohio	39	45	< 1	1
Delaware River				
Martins Creek, Pa.	13	21	0	0
Trenton, N.J.	17	33	0	0
Philadelphia, Pa.	23	59	0	1
Great Lakes				
Duluth, Minn.	5	20	0	0
Sault Ste. Marie, Mich.	10	11	0	1
Milwaukee, Wis.	12	27	0	0
Gary, Ind.	13	15	0	1
Port Huron, Mich.	11	15	0	0
Detroit, Mich.	11	16	0	0
Buffalo, N.Y.	14	21	0	0
Green River: Dutch John, Utah	20	31	6	6
Hudson River: Poughkeepsie, N.Y.	22	22	0	0
Illinois River				
Peoria, Ill.	17	45	3	4
Grafton, Ill.	—	—	—	—
Kanawha River: Winfield Dam, W. Va.	11	14	0	0
Klamath River: Keno, Ore.	18	23	1	2
Little Miami River				
Cincinnati, Ohio	74	154	1	2
Merrimack River: Lowell, Mass.	34	50	0	0
Mississippi River				
St. Paul, Minn.	23	25	1	1
Dubuque, Iowa	19	22	3	4
Burlington, Iowa	18	23	0	0
E. St. Louis, Ill.	—	—	—	—
Cape Girardeau, Mo.	31	31	4	5
W. Memphis, Ark.	10	29	0	2
Delta, La.	18	44	0	1
Vicksburg, Miss.	34	62	1	4
New Orleans, La.	21	25	1	3
Missouri River				
Williston, N. Dak.	3	7	8	13
Bismarck, N. Dak.	13	15	0	0
Missouri River—con.:				
Yankton, S. Dak.	28	36	12	13
Omaha, Nebr.	23	24	3	3
St. Joseph, Mo.	26	26	6	6
Kansas City, Kans.	40	48	4	4
St. Louis, Mo.	40	66	7	11
Missouri City, Mo.	33	44	4	5
Monongahela River: Pittsburgh, Pa.	13	15	0	0
North Platte River: Henry, Nebr.	55	65	30	31
E. Liverpool, Ohio	15	15	0	0
Addison, Ohio	24	46	1	1
Huntington, W. Va.	24	32	0	0
Cincinnati, Ohio	16	35	0	0
Louisville, Ky.	20	45	0	2
Evansville, Ind.	12	53	0	2
Cairo, Ill.	20	82	1	12
Ouachita River: Bastrop, La.	37	58	1	2
Pend Oreille River				
Albeni Falls Dam, Idaho	19	31	< 1	1
Platte River: Plattsmouth, Nebr.	36	48	5	6
Potomac River				
Williamsport, Md.	—	—	—	—
Great Falls, Md.	17	63	0	1
Rainy River				
Baudette, Minn.	16	19	0	0
International Fls, Minn.	24	29	0	0
Red River: Grand Forks, N. Dak.	25	37	2	2
Red River, South				
Denison, Tex.	51	56	3	3
Index, Ark.	32	58	5	7
Alexandria, La.	30	73	0	2
Bossier City, La.	49	107	1	2
Rio Grande River				
Alamaso, Colo.	5	5	1	1
El Paso, Tex.	9	21	8	9
Laredo, Tex.	26	84	6	7
Brownsville, Tex.	17	26	5	6
Roanoke River				
John H. Kerr Resr. & Dam, Va.	13	24	0	0
Sabine River: Ruliff, Tex.	64	112	0	2
Sacramento River				
Greens Landing, Courtland, Calif.	9	21	1	1
San Joaquin River: Vernalis, Calif.	28	39	3	3
San Juan River: Shiprock, N. Mex.	48	73	8	8
St. Lawrence River: Massena, N.Y.	13	15	0	0
Schuylkill River: Philadelphia, Pa.	25	104	0	0
Savannah River				
North Augusta, Ga.	20	35	0	1
Port Wentworth, Ga.	36	54	0	0
Shenandoah River: Berryville, Va.	16	36	1	1
Ship Creek: Anchorage, Alaska	12	22	0	1
Snake River				
Ice Harbor Dam, Wash.	17	30	2	2
Wawawai, Wash.	15	16	3	3
Payette, Idaho	27	37	5	5
South Platte River: Julesburg, Colo.	90	109	38	40
Spokane River: Post Falls, Idaho	14	24	0	0
Susquehanna River				
Sayre, Pa.	15	21	0	0
Conowingo, Md.	16	24	0	0
Tennessee River				
Chattanooga, Tenn.	33	46	0	0
Bridgeport, Ala.	24	44	0	0
Pickwick Landing, Tenn.	39	53	0	0
Lenoir City, Tenn.	21	37	1	1
Tombigbee River: Columbus, Miss.	15	39	0	0
Truckee River: Farad, Calif.	5	5	0	0
Verdigris River: Nowata, Okla.	38	108	1	10
Wabash River: New Harmony, Ind.	40	68	1	1
Willamette River: Portland, Ore.	26	52	0	0
Yakima River: Richland, Wash.	12	20	< 1	< 1
Yellowstone River: Sidney, Mont.	16	23	3	3

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[a] These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the Network's *Annual Compilation of Data (7)*.

[b] Dashes indicate data not available.

samples are taken weekly, monthly, or continuously, depending on the type of analysis to be performed and on the water quality. These samples are then analyzed for plankton population, organic chemicals, radioactivity, and chemical, biological, and physical quality (*1*, *2*).

Radioactivity associated with dissolved solids provides a rough measure of levels which may be found in treated water, since nearly all of the suspended matter is removed by treatment processes (*3*). It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity whereas fallout contributes primarily additional beta activity. Gross alpha and beta measurements are made on both suspended and dissolved solids (strontium-90 on the total solids only) in raw surface water samples according to established procedures (*4*, *5*).

For the first two years of the network's operations, beta determinations were made on weekly samples, and alpha determinations were generally made on composites of more than one weekly sample. From January 1960 to September 1961, alpha and beta determinations were generally made once a month on weekly composited samples. Beginning in September 1961, alpha determinations have been made on one sample each month, and beta determinations have generally been made on weekly samples. For the first operating year of each new station, sampling, and alpha and beta analyses are done weekly.

It at any time activity significantly greater than the normal environmental levels has been noted, the rate of sampling and analysis has been increased to at least once every week. Since January 1959, a portion of each sample from all stations in the network has been composited into a three-month station sample for measurement of strontium-90 (*6*). Because strontium 90 analyses are done quarterly, the results will be published on this basis.

Table 1 presents the results of the alpha and beta analyses on raw surface waters in the United States for January 1963. These data are preliminary; reanalysis of some samples may be made and additional analyses, not completed at the time of the report, may become available. For final data one should consult the Network's *Annual Compilation of Data* (*7*).

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the total beta activity (pc/liter) in suspended-plus-dissolved solids in raw water collected at that station in January 1963.

REFERENCES

(*1*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data*, PHS Publication No. 663, 1960 Edition, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

(*2*) Setter, L. R., and S. L. Baker: Radioactivity of Surface Waters in the United States, *Radiological Health Data, 1*:20-31 (October 1960).

(*3*) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association, 53*:704 (June 1961).

(*4*) Setter, L. R., J. E. Regnier, and E. A. Diephaus: Radioactivity of Surface Waters in the United States, *Journal of the American Water Works Association, 51*:1377 (November 1959).

(*5*) Robert A. Taft Sanitary Engineering Center, Public Health Service: *Radionuclide Analysis of Environmental Samples*, Technical Report, R59-6 (1959).

(*6*) Straub, C. P., L. R. Setter, A. Goldin and P. F. Hallbach: Strontium-90 in Surface Waters in the U. S., *Journal of the American Water Works Association, 52*:756 (June 1960).

(*7*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data*, PHS Publication No. 663, 1962-1963 Edition, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (To be published).

Radiostrontium in Tap Water[1]
July - December 1962

Health and Safety Laboratory U. S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 concentrations in tap water at New York City since August 1954 and at Richmond, California, since April 1958. Each sample analyzed is a monthly composite of daily samples. Also, determinations of strontium-89 have been made since September 1961 (*1*).

Data for the past several years are plotted in figure 1. Data prior to 1958 appear in an earlier HASL report (*2*). Strontium-90 concentrations and strontium-89/strontium-90 ratios for July through December 1962 appear in table 1.

TABLE 1.—RADIOSTRONTIUM IN TAP WATER

Month	New York City[a]		Richmond, California[b]	
	Sr^{90} (pc/liter)	Sr^{89}/Sr^{90}	Sr^{90} (pc/liter)	Sr^{89}/Sr^{90}
1959 Average	0.40		0.29	
1960 Average	0.47		0.26	
1961 Average	0.32		0.25	
1962 First quarter	0.51		0.27	
1962 Second quarter	0.60		0.23	
July[c]	0.88	3.0	0.14	2.9
August[c]	0.82	2.7	0.17	2.7
September[c]	1.05	1.8	0.18	1.4
October[c]	0.87	lost	0.28	3.6
November[c]	0.84	4.7	0.14	2.4
December[c]	0.82	3.9	0.30	3.4

[a] From 100-200 liters per sample.
[b] Approximately 100 liters per sample.
[c] Strontium-89 extrapolated to midpoint of sampling period.

Monthly average strontium-90 concentrations in tap water at New York City reached a record high of 1.05 pc/liter in September 1962 but averaged between 0.8 and 0.9 during the last two quarters of 1962. Levels at Richmond, California have never been as high as those observed in New York, ranging between 0.14 and 0.35 pc/liter during 1962.

The strontium-89/strontium-90 ratios indicate that the fallout was probably not of any more recent origin when strontium-90 concentrations were high than when they were low.

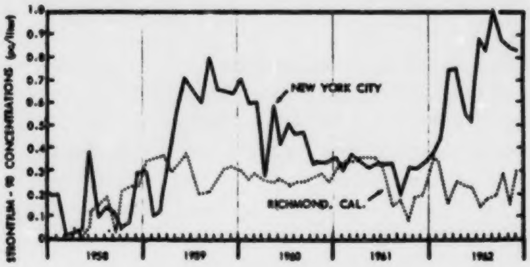

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN TAP WATER

The maximum strontium-90 concentrations observed are well below the acceptable limit of 10 pc/liter as set forth in the interstate carrier drinking water standards (*3*).

REFERENCES

(*1*) U. S. Atomic Energy Commission: *Fallout Pr gram Quarterly Summary Report, HASL-135*:151, Office of Technical Services, Department of Commerce, Washington 25, D. C. (April 1, 1963), price $3.00.

(*2*) U. S. Atomic Energy Commission: *Environmental Contamination from Weapons Tests, HASL-42*, Office of Technical Services, Department of Commerce, Washington 25, D. C. (October 1962), price $3.50.

(*3*) Federal Register Rules and Regulations: *Title 42—Public Health Chapter 1—Public Health Service, Department of Health, Education, and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards, 27*:2154-5, Superintendent of Documents, Government Printing Office, Washington 25, D. C. (March 6, 1962).

Recent coverage in *Radiological Health Data:*

Period	Issue
First quarter 1961	*December 1961*
Second quarter 1961	*March 1962*
Third and fourth quarters 1961	*June 1962*
January-April 1962	*September 1962*
March-June 1962	*January 1963*

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[1] Data taken from *HASL-135* (*1*).

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SECTION V.—OTHER DATA

Radiation Levels Aboard Commercial Jet Aircraft Resulting From Atmospheric Nuclear Weapons Tests

November 1961 - December 1962

Donald J. Nelson, Caleb B. Kincaid and Richard L. Mikkelsen

This report presents data and interpretation of radioactivity findings on commercial jet aircraft during periods of atmospheric nuclear weapons testing. Data presented were obtained through cooperative monitoring systems of the U. S. Public Health Service (PHS), the Federal Aviation Agency (FAA), and the airline industry through the Medical Committee of the Air Transport Association (ATA). The program is a continuation and expansion of cooperative activities with Pan American World Airways initiated in April 1959. The following data are reported for the period November 1961 through December 1962: film badge and pocket dosimeter measurements of external gamma radiation during commercial jet flights, determinations of gross beta activity and gamma emitters in cabin air, and surface radioactivity measurements by G-M survey meters and by filter paper swipes of contaminated aircraft surfaces.

The program monitored the following categories of flights originating in and returning to the United States: (a) *polar*, a flight going through or near the arctic region; (b) *equattorial*, a flight continuing near or along the equator; (c) *longitudinal*, a flight toward or across the equator and stopping at various Central and South American cities; (d) *latitudinal*, which includes transcontinental and European flights. Not all monitoring measurements were made on all flight categories; hence, the nature and extent of the measurements are described separately in each section.

External Gamma Radiation Levels

Dosimetry devices, consisting of film badges and pocket dosimeters provided by the Public Health Service, were placed in cockpits or baggage compartments on routine flights of jet aircraft. The dosimetric films exposed in flight and control films retained at the flight origin were returned to a commercial supplier for processing and reporting of exposures recorded.

The routes flown are indicated in figure 1. Air carriers whose flights were monitored for gamma radiation were: Pan American World

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Airways, Inc.; Pan-American-Grace Airways, Inc. (Panagra); Eastern Air Lines, Inc.; Trans World Airlines, Inc.; Northwest Airlines, Inc.; and United Airlines, Inc.

During the period from November 1961 through December 1962, a total of 725 film packs were exposed during flights, of which 700 indicated that the total gamma exposure in cockpits or baggage compartments was less than 10 mrem and twenty-five films indicated levels above 10 mrem, with the highest single exposure recorded being 640 mrem.

In the case of each exposure above 10 mrem, an investigation was made, revealing that in every instance the reported exposure was due to a source other than fallout debris. One such case was found to be due to a nonradiation caused darkening of the film caused by excessive heat during the flight. Other film exposures showing values in excess of 10 mrem were traced to radioactive isotope shipments in the baggage compartment near the film pack. These findings confirm previous estimates of limited external radiation exposure to passengers and crews abroad commercial jet aircraft (*1*).

Cabin Air Radiation Levels

Previous studies (*1-5*) have shown that minimum levels of airborne radioactivity are

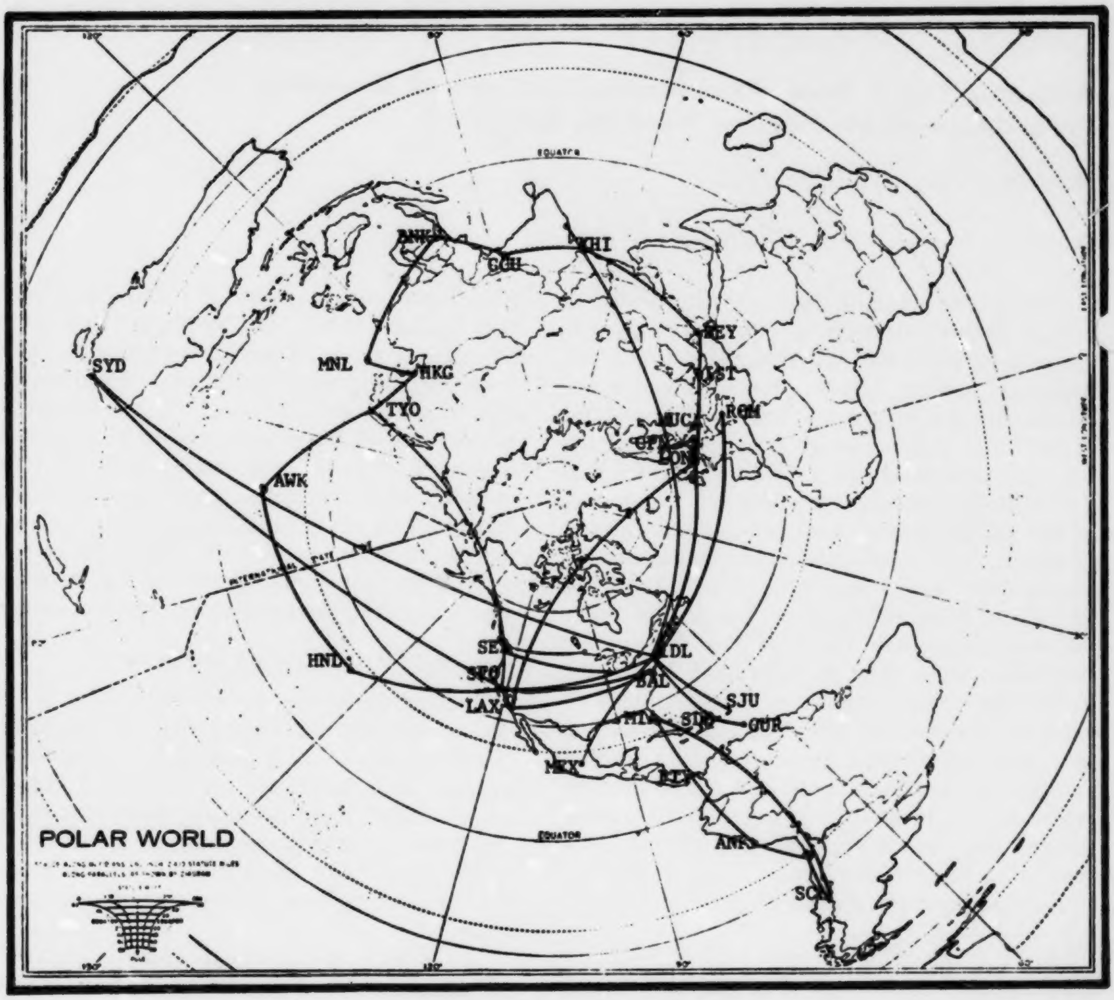

FIGURE 1.—AIRLINE ROUTES FLOWN WITH FILM BADGES ABOARD

found in commercial aircraft over regular routes during weapons test operations. Restrictions of commercial air traffic in the vicinity of test sites during operations have prevented interception of fresh fission product clouds. To make a further survey of cabin air radioactivity levels, an air pump sampler with a membrane filter was carried aboard aircraft in transcontinental U. S. service. A portion of the intake air to the passenger compartment was passed through the membrane filter during flight. Filter paper samples were sent to the PHS laboratory at Rockville, Maryland, for gross beta determinations and scanning for identification of gamma emitters. Table 1 summarizes the results. The highest level of residual gross beta activity recorded was 270 pc/m³. During the sampling period from February 25, 1962 to August 3, 1962, the higher beta activity levels were observed in the early spring months (range 2 to 270 pc/m³) as compared to the later portion of the sampling period (range 0.66 to 19 pc/m³).

TABLE 1.—LEVELS OF RESIDUAL GROSS BETA ACTIVITY IN AIR COLLECTED IN VENTILATION SYSTEM OF COMMERCIAL AIRCRAFT IN FLIGHT

Date 1962	Flight path [a]	Aircraft	Residual gross beta activity (pc/m³) [b]
February 25	IDL to LAX	#N520	3.8
March 8	IDL to LAX	#N7520	130
April 22	IDL to LAX	#N512	91
April 27	LAX to IDL	#N512	75
May 3	IDL to LAX	#N520	65
May 6	IDL to LAX	#N517	56
May 10	LAX to IDL	#N520	270
May 10	IDL to LAX	#N520	2.9
May 13	LAX to IDL	#N512	29
May 22	LAX to IDL	#N512	24
May 26	LAX to IDL	#N512	36
May 31	IDL to LAX	#N512	2
May 28	LAX to IDL	#N520	3
May 28	IDL to LAX	#N7512	46
June 4	LAX to IDL	#N520	3.1
June 3	LAX to IDL	#N520	3.3
June 10	IDL to LAX	#N7520	1.9
June 10	IDL to LAX	#N512	8.9
June 10	LAX to IDL	#N520	2.1
June 17	IDL to LAX	#N7520	3.9
June 11	LAX to IDL	#N512	5.1
June 12	IDL to LAX	#N520	4
June 21	LAX to IDL	#N512	7.1
June 21	IDL to LAX	#N7520	2
June 28	IDL to LAX	#N520	1.2
July 1	LAX to IDL	#N520	0.88
June 28	LAX to IDL	#N520	0.66
July 2	IDL to LAX	#NB520	0.74
July 3	IDL to LAX	#N520	6
July 5	IDL to LAX	#N520	2.4
July 8	LAX to IDL	#N520	1.9
July 8	IDL to LAX	#N520	1.4
July 10	LAX to IDL	#N520	1.7
July 8	LAX to IDL	#N520	2.4
July 16	LAX to IDL	#N520	1.4
July 13	IDL to LAX	#N520	2.1
July 20	IDL to LAX	#N520	1,5
July 23	LAX to IDL	#N512	19
August 3	LAX to IDL	#N512	3.7

[a] IDL: Idlewild, LAX: Los Angeles.

[b] Sampling is by air pump with membrane filter operating aboard aircraft of American Airlines, Inc. with analyses performed by internal gas flow proportional counters at Radiological Health Laboratory, Public Health Service, Rockville, Maryland. Analyses are performed within five days of collection. Calibration standards are Sr^{90}-Y^{90}.

Aircraft Surface Surveys

The monitoring of aircraft surfaces for radioactive contamination by means of G-M type survey meters has been practiced by industry and government for years. Since 1959 the PHS has been receiving data from the airline industry for collation and evaluation. During the 1959-1961 moratorium on atmospheric weapons testing, surveys by the industry revealed a gradual decline of radioactive contamination levels on commercial jet aircraft in normal operation. With the resumption of atmospheric weapons testing in 1961, the PHS in cooperation with the Medical Committee of the ATA arranged for an expanded program of monitoring jet aircraft contamination. Radiation surveys were conducted by commercial airlines, and the findings of periodic inspections were sent to the Division of Radiological Health for evaluation and computation. Polar, equatorial and longitudinal flights were included in the survey. The aircraft which flew the polar and equatorial flights were Boeing 707 models; those which flew the longitudinal flights were generally Douglas DC-8 aircraft.

A survey of the entire surface of a craft would be exceedingly time consuming. On the basis of experience in previous aircraft surveys, it was concluded that significant contamination tended to be distributed where oil or grease collected and where there was a disturbance of air flow over the fuselage.

Because of differences in design of the two types of aircraft participating in the study, the areas selected for measurement of radioactivity were different. Figure 2 shows outlines of the B-707 and DC-8, and identifies the areas subjected to sampling and measuring of radioactivity.

The amount of radioactivity at the specified points was determined by using a G-M type survey meter—a THYAC Model 489-4 with a Victoreen 1B85 G-M tube, which can measure either beta and gamma fields or just gamma radiation. This type of meter is similar to the low range beta-gamma survey meter described by FAA (2). When the instrument window is open, both beta and gam-

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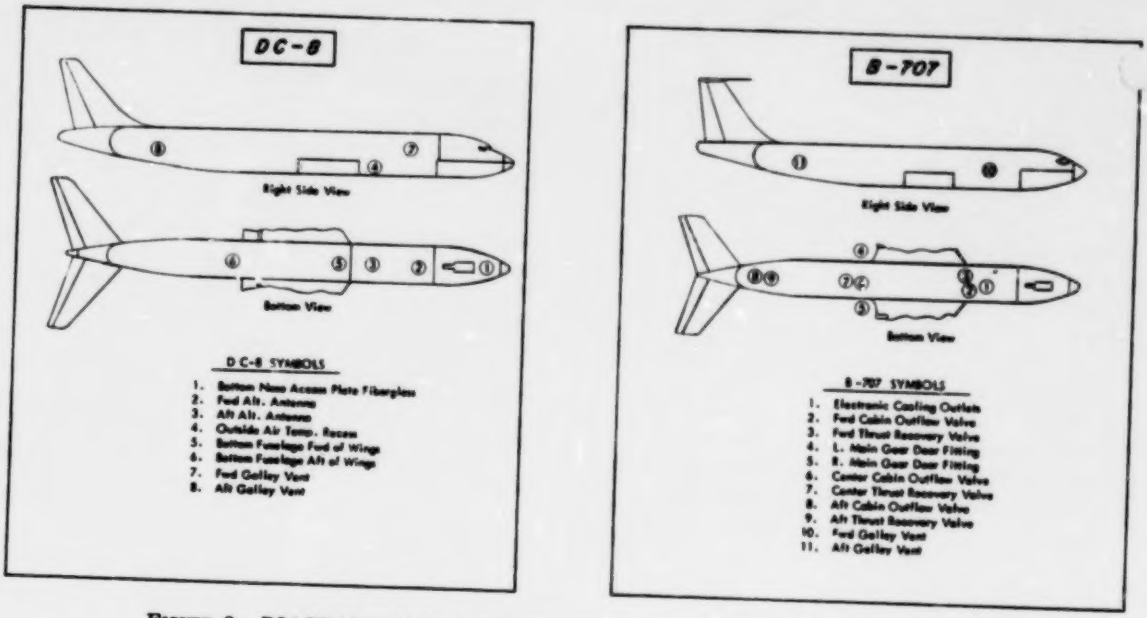
DC-8
Right Side View
Bottom View
D C-8 SYMBOLS
1. Bottom Nose Access Plate Fiberglass
2. Fwd Alt. Antenna
3. Aft Alt. Antenna
4. Outside Air Temp. Recess
5. Bottom Fuselage Fwd of Wings
6. Bottom Fuselage Aft of Wings
7. Fwd Galley Vent
8. Aft Galley Vent
B-707
Right Side View
Bottom View
B-707 SYMBOLS
1. Electronic Cooling Outlets
2. Fwd Cabin Outflow Valve
3. Fwd Thrust Recovery Valve
4. L. Main Gear Door Fitting
5. R. Main Gear Door Fitting
6. Center Cabin Outflow Valve
7. Center Thrust Recovery Valve
8. Aft Cabin Outflow Valve
9. Aft Thrust Recovery Valve
10. Fwd Galley Vent
11. Aft Galley Vent

FIGURE 2.—DIAGRAMMATIC REPRESENTATION OF AREAS MONITORED

ma radiation field levels are recorded; when the window is closed, the beta activity is filtered out and only gamma levels are recorded. During readings, the instrument was held one inch from the surface of the aircraft to obtain standardized readings.

Alpha activity is not detected by this means; however, alpha contamination is not considered a controlling factor in exposure of personnel in or about the aircraft in commercial operation. Routine laboratory examinations of material wiped from the surface were made to assure that alpha contamination is not a problem.

After completion of a flight, the aircraft was monitored for surface radioactivity with the G-M survey meter. This measurement may or may not be cumulative from several flights because the planes were cleaned of radioactivity when the activity on any external portion of the plane produced a beta-gamma reading above 2.5 mr/hr. Detailed descriptions of various cleaning methods for different types of surfaces, and other related considerations, are included in the FAA Manual (*2*).

For the purposes of this study, it was considered necessary only to record the radioactivity on the basis of generalized flight routes and not to evaluate each individual flight. A detailed study would necessitate alteration of present techniques in order to either remove from consideration or evaluate adequately the numerous variables involved, such as: (1) variation in flight time; (2) variation in air speed and air currents; (3) variation in altitude of flight; and (4) variation in areas over which the craft flew. These variations exist for the flights classified under each generalized route; hence, the organization of flight data along general routes is justified for reasons dictated by practicality, and is necessary to provide a method of analysis and concise presentation.

Data sheets completed by representatives of the Association contained: survey instrument readings in counts per minute (cpm) and in mr/hr for each of the specified points on the aircraft; departure and arrival dates; readings; number of hours in flight; and cleaning operations. The background radiation at the place of measurement, determined before each set of readings, averaged 100 cpm or 0.025 mr/hr. The background radiation is included in the tabulated values.

Survey Meter Measurements—The daily aver-

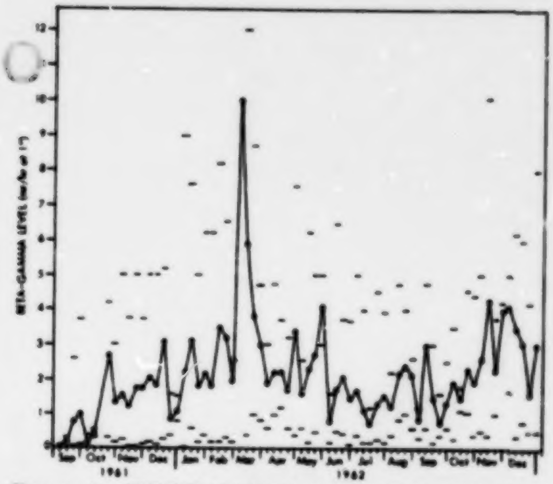

FIGURE 3.—WEEKLY HIGH, LOW, AND AVERAGE BETA-GAMMA LEVELS ON FORWARD THRUST RECOVERY VALVES ON BOEING 707 AIRCRAFT OVER LATITUDINAL, EQUATORIAL, AND POLAR ROUTES

age level of radioactivity was obtained by averaging the individual values recorded at the specified points on the aircraft. In several instances more than one daily average was obtained for a particular day. The daily average beta-gamma activity levels were plotted to present a visual picture of the variations in radionuclide concentration on the external surfaces of the aircraft. To show the variation in level of radioactivity at one representative point, the weekly average beta-gamma activity levels at the forward thrust recovery valve after each flight were plotted (figure 3).[2] The monthly average activity concentrations, derived by averaging daily average values during a monthly period, are shown in figure 4.

During the period of this study, at least three major nuclear weapons test series were announced, involving well over 100 tests by the U.S.S.R. and the United States at a number of test sites. Since fallout debris can remain in the atmosphere for long periods subject to dynamics of the upper and lower atmosphere, it would be extremely difficult or impossible to attribute any concentration of contamination on an aircraft surface to a particular test or series of tests. The variable in question is the time interval between a test and the recording of the resulting high concentrations aboard a particular aircraft. This variable can be eliminated to some extent when considering a series of high-yield nu-

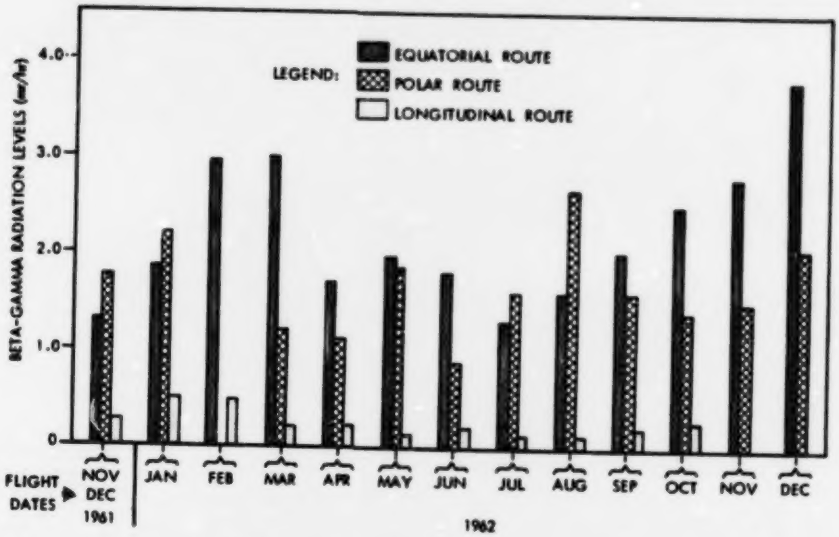

FIGURE 4.—MONTHLY AVERAGE LEVELS OF FISSION PRODUCT CONTAMINATION ON EXTERNAL SURFACES OF COMMERCIAL AIRCRAFT, FLOWN OVER EQUATORIAL, LONGITUDINAL, AND POLAR ROUTES

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[2] The beta-gamma values in figures 3, 4, 6, and 7 represent instrument readings, expressed in terms of mr/hr.

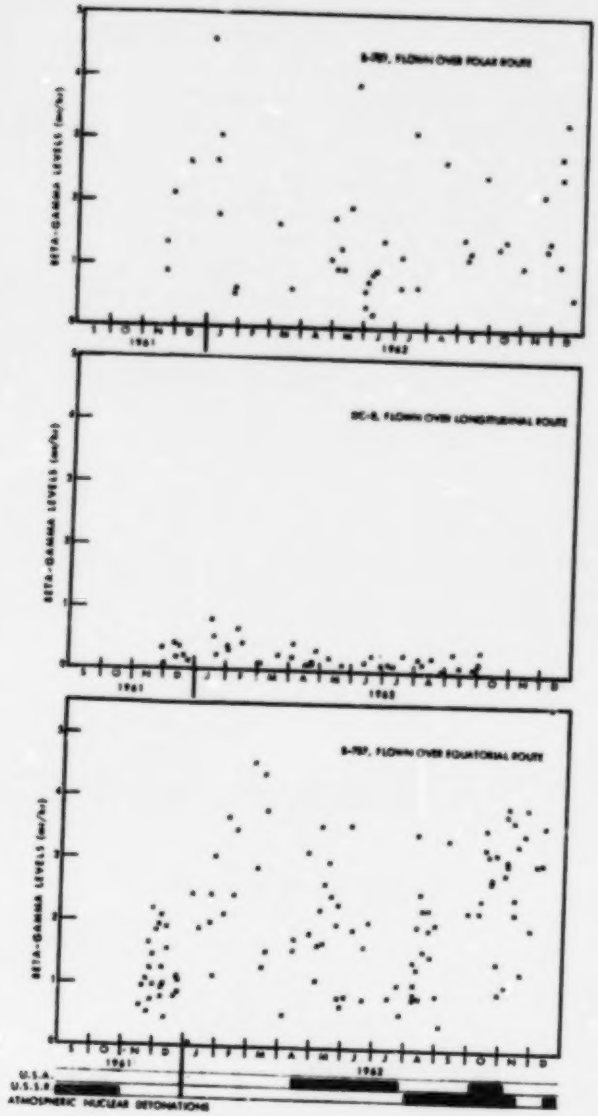

FIGURE 5.—BETA-GAMMA RADIATION FIELD MEASUREMENTS ONE INCH FROM EXTERNAL SURFACES OF COMMERCIAL AIRCRAFT

clear tests. An example of this may be the high peaks recorded on the polar route during December 1961 - January 1962 and those recorded on the equatorial route during February-March 1962. These peaks may represent the delayed effects of the extensive U.S.S.R. testing series during September to early November 1961; most of these detonations were in the high-yield range. The low levels of radioactivity recorded on the longitudinal route are attributable to the fact that most of the nuclear testing took place in the Northern Hemisphere.

Figure 5 plots the radiation levels measured near the surfaces of aircraft flying different routes, in terms of beta-gamma levels (mr/hr) at 1 inch distance from the surface, for the period November 1961-December 1962. For purposes of reference, a bar chart showing announced atmospheric detonations appears beneath figure 5.

Filter Paper Swipes—To establish the nature of the contamination collected on the aircraft surfaces during operation, a special sampling procedure was initiated to determine radionuclide composition. To obtain a sample for laboratory analysis, a two-inch diameter filter paper was used to wipe one square foot of the contaminated surface. The filter paper sample was counted by means of a laboratory gas-flow proportional beta counter calibrated by strontium-90 standards. Results were reported as gross beta activity in pc per 2-inch filter paper circle and were converted to pc/cm^2 by using

TABLE 2.—SUMMARY OF RESULTS OF SURVEY METER READINGS AND LABORATORY ANALYSIS OF FILTER PAPER SWIPE SAMPLE[a]

Survey meter results[b]			Beta activity in pc removed per cm^2 by 2 inch circle of filter paper[d]	Estimated percent removed by wiping
cpm	mr/hr $\beta-\gamma$	Total pc cm^2[c]		
13,000	3.25	9,750	80	0.8
10,000	2.50	7,500	71	0.9
10,000	2.50	7,500	55	0.7
1,000	0.25	750	9	1.2
350	0.09	270	2	0.7
10,000	2.50	7,500	122	1.6
5,300	1.32	3,960	52	1.3
600	0.15	450	39	0.9
4,000	1.00	3,000	33	1.1
550	0.14	420	4	0.3
1,000	0.25	750	7	0.9
1,500	0.37	1,110	6	0.5
4,500	1.12	3,360	20	0.5
8,000	2.00	6,000	31	0.5
4,500	1.12	3,360	15	0.4
1,200	0.30	900	3	0.3
1,200	0.30	900	7	0.8
4,300	1.07	3,210	15	0.5
6,700	1.67	5,010	30	0.8
2,000	0.50	1,500	6	0.4
6,000	1.50	4,500	35	0.8
1,500	0.37	1,110	3	0.3
1,800	0.45	1,350	12	0.9
5,300	1.32	3,960	45	1.1

[a] From surfaces of commercial jet aircraft in operation out of Idlewild International Airport, Pan American Airways, October to December, 1961.

[b] As determined by aluminum wall Geiger-Mueller survey meter at one inch from contaminated surface.

[c] Using the conversion 1 mr/hr $\beta-\gamma \cong 3{,}000$ pc/cm^2.

[d] As determined by analysis in gas flow proportional beta counter.

the simple conversion factor 930 cm^2/ft^2. Difficulties in obtaining an accurate sample of a square foot of surface prevented a reliable conversion to activity per unit area, but the estimates shown in table 2 indicate the degree to which activity was removed by this procedure.

Table 2 also shows readings made with an aluminum wall G-M survey meter at a distance of one inch from the aircraft surface sampled. The reading was obtained with the beta shield open and is expressed as counts per minute (cpm). The approximate conversion for the instrument used is 4,000 cpm per mr/hr. The results given are for the period October-December 1961. Additional tests made during 1962 indicate that the activity deposited on aircraft surfaces has shown no significant variation in terms of radionuclides significant to health. The activity consists of fission products whose radionuclide composition varies with the age of the sample.

The most abundant gamma-emitting radionuclides found were cerium-141, cerium-144, ruthenium-rhodium-103, ruthenium-rhodium-106, zirconium-niobium-95, barium-lanthanum-140, and iodine-131. No specific determination was made for pure beta emitters, but the gamma scan findings are consistent with those of fission-produced weapons test debris generally one year of age or less. This agrees with similar determinations previously reported by other investigators (*1-5*).

Gamma scans were performed during the monitoring of aircraft surfaces for beta-gamma activity. The values found ranged from 0.01 to 0.19 mr/hr (except for a single reading of 0.69). The ratio of gamma to total beta-gamma activity varied considerably; however, as is evident from the scatter chart (figure 6), the gamma activity tended to increase as higher beta activity occurred. In general, the lowest gamma to beta ratios were found on aircraft flown over an equatorial route, while the highest ratios were observed on aircraft flying over the longitudinal and polar routes, in that order.

Interim Operating Guidelines

The bases for establishing guides for handling procedures in connection with fission product contaminated aircraft surfaces and parts follow. They are generally consistent with guides reported previously (*1, 3*).

In addition, the FAA Manual (*2*) should be referred to for guidance in determining cleaning methods to be used on the various types of surfaces, clothing to be worn, procedures for handling and cleaning engine components, and personnel precautions to be taken in order to minimize exposure of aircraft personnel should hazardous levels occur as a result of nuclear warfare or other radiological emergencies. In general, they include assumptions that: (1) fission product contamination is one year of age or less, with strontium-90 con-

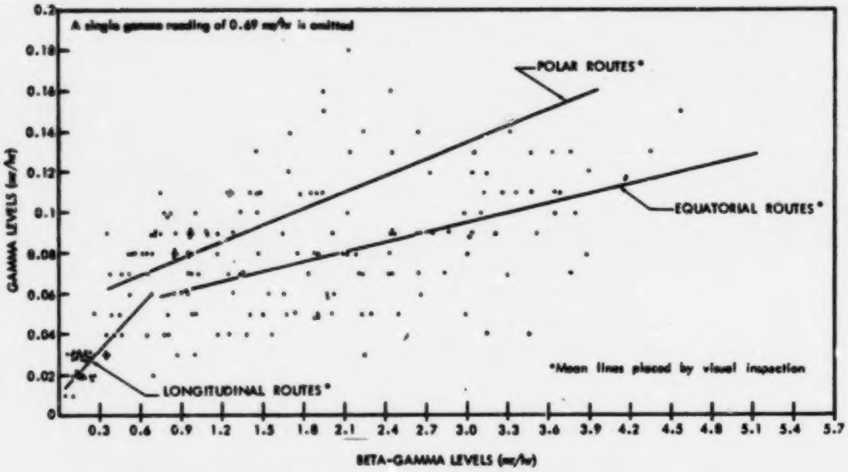

FIGURE 6.—RATIO OF GAMMA TO BETA-GAMMA LEVELS

tributing no more than 1 percent of the beta activity; (2) gamma field readings at 1 inch are not more than one-tenth the beta-gamma field readings at the same distance; (3) available contamination in terms of transfer to hands or gloves in ordinary handling is one-tenth the area contamination, and other routes of exposure such as inhalation are negligible; (4) not more than 50 percent of the material on hands or gloves is taken into the mouth as a result of eating or smoking; (5) the maximum surface contact time for hands during any week is 20 hours.

Previous investigations have indicated that with mixed fresh fission product (one year of age or less) debris on aircraft, the external radiation hazard is the principal factor and the inhalation and ingestion hazard may be ignored. This assumption is accepted in developing the exposure model, but only on the condition that proper precautions are taken with respect to personal hygiene in the handling of contaminated parts and surfaces. Nevertheless, a buildup of contamination levels may result in unique radiological situations in which a single ingestion may actually result in greater hazard to individuals than external gamma would produce.

The decontamination procedures referred to for air frames are those originally used in the commercial aircraft maintenance instructions, i.e., wet wash procedures including hosing and scrubbing with mops and detergents. Aircraft engines and parts receive a thorough cleaning during overhaul which is usually effective in removing contamination.

Although past experience indicates that aircraft radioactivity levels should not rise to hazardous proportions unless the aircraft penetrated a freshly formed cloud from a nuclear detonation, the PHS and the Medical Committee of the ATA drafted the foregoing operating guides for use by the airlines. The basic assumption was made that a reading from a properly calibrated G-M survey meter with aluminum wall detector, placed one inch from the contaminated surface, would give a meaningful indication of the contamination level. It was decided that if a nationwide program of monitoring all aircraft became necessary, the procedures for estimating contamination levels should be simple and operative at all locations where aircraft were berthed, maintained, or inspected. Figure 7 charts the minimal guidelines for suggested handli procedures.

With these assumptions, exposure values can be calculated for an aircraft surface showing a 20 mr/hr beta-gamma reading at one inch. The exposure from gamma radiation at a distance of one inch is assumed to be one-tenth of the total beta-gamma reading or 2 mr/hr. This would result in an annual external gamma exposure of 4.0 rem. The exposure value to the hands from beta radiation is calculated to be 20 mrem for each hour the hands are in contact with the contaminated surface.

Based on the above-mentioned assumptions it is possible that an individual could conceivably ingest up to 30 pc/day of strontium-90 for each cm^2 handled. To exceed the FRC Range II value for occupational exposure of 2,000 pc/day of strontium-90, the individual need only handle about 70 cm^2/day at the contamination level indicated. If the suggested "In Plant Handling Procedures" are followed, the ingestion of 2,000 pc of strontium-90/day becomes unlikely even though the individual handles many items or objects with bet gamma readings of 20 mr/hr.

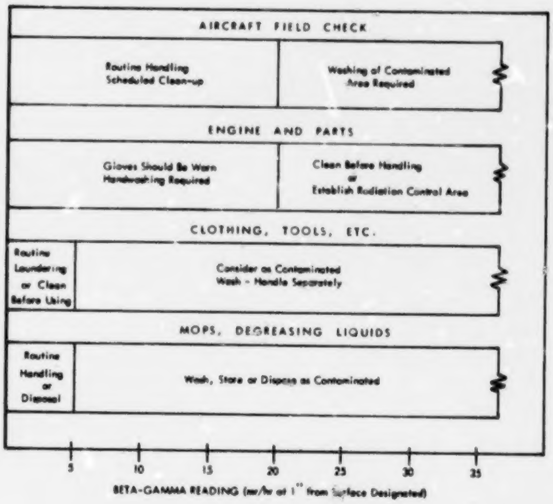

FIGURE 7.—MINIMAL SUGGESTED IN-PLANT HANDLING PROCEDURES FOR AIRCRAFT SUBJECTED TO FALLOUT

Summary

A review of the information obtained from radiological monitoring programs of the airline industry and the Public Health Service indicates that the operation of U. S. commercial jet aircraft over national and international routes during the period of weapons testing, November 1961 to December 1962, has resulted in negligible radiation exposure to passengers and crews. Contamination of aircraft by fission products does occur. The characteristics of the deposition are the same as reported in previous studies.

None of the readings indicate that a radiation hazard existed either to personnel associated with the aircraft or to passengers. Also, potential hazards are very small during nuclear testing, provided that the suggested handling procedures are followed to prevent extensive radioactivity contamination buildup on the aircraft. Airlines are encouraged to adopt handling procedures, wherever possible, which would limit radiation exposure of personnel and to utilize the guidance of the Federal Radiation Council (FRC) and the International Commission of Radiation Protection (ICRP) for evaluation of specific radiation exposure situations.

Acknowledgments

The assistance and cooperation of the Air Transport Association of America in the pursuance of this study is gratefully acknowledged. Special credit is extended to Mr. H. Grady Gatlin, Secretary, Medical Committee, ATA; Dr. Otis B. Schreuder, Medical Director, Medical Committee, ATA, and to the other Medical Directors of this Committee; Dr. Charles Gullet, Dr. George J. Kidera, Dr. L. G. Lederer, Dr. John R. McGraw, and Dr. Robert B. Pender. In particular, acknowledgement is made to Mr. Ernest J. Vajda, of the Technical Operations Branch, DRH, for his technical assistance.

REFERENCES

(*1*) Dick, J. L., M. C. Gaske, and L. A. Riley, Jr.: Evaluation of Personnel Exposure from Stratospheric Fission Fragment Contamination on Aircraft, *Aerospace Medicine*, *31*:353-71, (May 1960).

(*2*) Federal Aviation Agency: *Radiological Protection and Decontamination of Civil Aircraft*, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (November 1962).

(*3*) Kulp, J. L., and J. L. Dick: The Radiation Hazard from Contaminated Aircraft, *Health Physics*, *4*: 133-56, (1960).

(*4*) Defense Atomic Support Agency, Department of Defense: High Altitude Sampling Program, *Radiological Health Data*, *2*:426-9, (October 1961).

(*5*) Neill, Robert H.: Radioactive Contmination of Jet Aircraft, *Radiological Health Data*, *2*:83-9, (February 1961).

Strontium-90 Content of Human Bone Specimens, 1960-1961[1]

P. G. Mar[2]

Introduction

The Radiation Protection Division's program for the determination of strontium-90 in human bone specimens was continued in 1961 in the same way as in preceding years. Post-mortem samples of vertebrae were collected through the cooperation of hospital pathologists in all the larger medical centers. A total of 634 samples have been received. However, over 70 percent of these were from subjects aged 40 years or more. Only a very few suitable samples of children's bones, which are of special importance in this study, were obtained.

Method

Except for a few minor adaptations, the method used for analysis of the bone samples was essentially the same as that for milk powder (*1*). The strontium-90 content was determined by adding stable strontium carrier, separating the strontium chemically, then determining the beta activity of the yttrium-90 daughter-product of the strontium. Calcium was determined by flame spectrophotometry. The results are reported as picocuries of strontium-90 per gram of bone calcium. The natural content of ordinary, non-radioactive strontium in the bone specimens was not estimated, and therefore no correction for this was made in the determination of the chemical recovery of the carrier.

Results

The results are given in table 1, classified into the same age classes as were used in previous years. However, for some of the classes only a very small number of samples is included and for these the "average" value is, of course, subject to a large probable error. A statistical analysis will be carried out when more data are available.

It will be seen that the average values for 1961 show only a very slight increase over the corresponding averages for 1960 (*2*).

Acknowledgments

The analytical work was carried out by J. Fenning, J. Quinn and C. Reynolds.

REFERENCES

(*1*) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, RPD-5*, Radiation Protection Division, Department of National Health and Welfare, Ottawa, Ontario, Canada (June 1, 1960).

(*2*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-(RP-4)*, Radiation Protection Division, Department of National Health and Welfare, Ottawa, Ontario, Canada (December 1961).

Previous coverage in *Radiological Health Data:*

Period	*Issue*
1957 and 1958	*February 1961*
1960	*September 1962*

TABLE 1.—STRONTIUM-90 IN HUMAN BONE, 1960-1961

Age group	1960			1961		
	Number of subjects	Strontium-90 (pc/g Ca)		Number of subjects	Strontium-90 (pc/g Ca)	
		Average	Range		Average	Range
0- 1	117	1.52	0.77-3.71	1	2.11	
1- 5	8	1.58	0.65-3.31	5	1.99	0.58-3.38
6- 9	11	1.48	0.83-3.07	1	2.21	
10-19	24	1.41	0.59-2.75	5	1.79	0.83-2.81
20-29	15	0.96	0.39-1.52	12	1.08	0.40-1.77
30-59	65	0.92	0.33-1.97	49	1.01	0.49-3.04
Over 60	34	0.87	0.40-2.16	26	0.92	0.58-1.59

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[1] Abstracted from Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW (RP-5), Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada, December 1961.

[2] Dr. Mar is Radiochemist-in-Charge, Caldwell Avenue Laboratory, Radiation Protection Division, Ottawa, Ontario, Canada.

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Strontium-90 in Canadian Soils, 1960-1961[1]

H. Taniguchi[2]

Introduction

In 1960, the Radiation Protection Division's radioactive fallout monitoring program was extended to include the assay of strontium-90 in undisturbed (non-agricultural) soils on an annual basis. These data were required to complement the information obtained through the monitoring of fallout in air and in precipitation (*1*). In some fallout studies, it is important to know not only the incremental amounts deposited on the ground in a given period, but also the total integrated amount from all the nuclear weapons testing carried out over the years. If a soil sample is obtained from a carefully selected site, the strontium-90 in it can be assumed to represent the total amount that has reached the ground at that location.

Sampling Sites and Method

Before the Radiation Protection Division's soil monitoring program was started, samples from selected Canadian sites had been taken by the U. S. Department of Agriculture and analyzed by the Health and Safety Laboratory of the Atomic Energy Commission (*2-5*) as part of a study of world-wide fallout patterns. The experience of the scientists engaged in this work was drawn upon in initiating the present program, particularly in the selection of suitable sampling sites.

Sampling was initiated at twenty-two of the stations across Canada at which monitoring is presently being carried out for radioactivity in air and precipitation.

The actual sampling sites at Montreal, Ottawa, Toronto, and Windsor were selected personally by Dr. L. T. Alexander of the U. S. Department of Agriculture, to emulate the choice of locations made in the U. S. program. The requirements for a suitable sampling site are: (a) the site should be nearly level, (b) the soil should have moderate to good permeability, (c) there should be little or no run-off during heavy rains, (d) there should be no over-wash at any time, (e) there should be no cropping or removal of vegetation, (f) there should be no dust from roads, and (g) the site should be located far enough away from buildings or trees which may affect the wind and precipitation pattern (*6*). The other sites were chosen with the advice of Dr. A. Leahey, Canada Department of Agriculture, to meet these requirements as closely as possible.

The samples were taken using a 3.5-inch diameter "cookie cutter" to cut through the turf to a depth of 2 inches. Sampling to a depth of 6 inches was then completed with a 3.25-inch diameter barrel orchard auger which cut a 3.5-inch diameter hole. Twenty individual cores were taken about a foot apart in a line and composited to give a sample representing 1.34 square feet (0.124 square meter). In subsequent years, the sample was taken in a line parallel to the previous year's, with a separation of about 3 feet between the lines.

Preparation of the Samples

The complete sample, as received, was dried in a forced circulation oven at 110° C. The sample (including stones) was then crushed with a laboratory crusher to a size suitable for passing through a pulverizer. The resulting fine powder was thoroughly blended using a laboratory blender. Aliquots from this homogeneous mix were taken for analysis.

The samples collected during 1960 (except in Halifax, Nova Scotia) were prepared for analysis at Beltsville, Maryland, by the U. S. Department of Agriculture. Aliquots of the prepared samples were obtained for analysis by the Radiation Protection Division.

Method of Analysis

The method of analysis followed closely that recommended by Hamada and Hardy

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[1] Abstracted from Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW (RP-5), Radiation Protection Division, Department of National Health and Welfare, 370 Sparks Street, Ottawa, Ontario, Canada.

[2] Dr. Taniguchi is Radiochemist with the Radiation Protection Division of the Canadian Department of National Health and Welfare.

(*7*) in which, after the addition of stable strontium carrier the sample is leached with 6N hydrochloric acid. Alkaline earth oxalates are then precipitated from the leach solution. The oxalates are converted to nitrates and strontium is separated from the calcium by repeated precipitations with fuming nitric acid. This strontium is scavenged of barium, traces of lead and radium activities, until radiochemically pure. The amount of strontium-90 is then determined by separating, purifying, and counting its radioactive daughter, yttrium-90.

The efficiency of the 6N hydrochloric acid extraction of the strontium-90 may be expected to vary somewhat for different types of soil. For samples collected in the U. S. program during 1958, Hardy (*8*) has shown that the percentage of strontium-90 extracted varied from 71 to 97 percent. The average efficiency of the acid extraction of soils collected during 1969, covering a wide range of geographical locations and strontium-90 content, was 87 ± 8 percent, with a range of 78 to 101 percent (*9*). The present results, therefore, can be expected to be subject to an error of this order of magnitude.

It should be noted also that in calculating the results, the recovery of the strontium carrier was not corrected to take into account the natural strontium that may have been present in the soil. The presence of any natural strontium would make these uncorrected results low. The effect can be reduced by using a large amount of carrier; in the present work, 200 mg of strontium carrier were added to each 500 grams of soil analyzed. Despite this, there remains the doubt that some soils could have contained sufficient natural strontium to introduce an appreciable error. In future work, this uncertainty is to be resolved by the use of a tracer technique.

Results and Discussion

The results of the analyses for soils collected during the summers of 1960 and 1961 are presented in table 1, expressed as nanocuries of strontium-90 per square meter. No marked geographical differences are apparent except for the lower values at the more northerly stations. The national averages for 1960 and 1961 were, respectively, 15.8 and 15.4 nanocuries per square meter. Most of the stations are located between the 42nd and 60th latitudes. The average values in this zone were 17.2 and 16.9 millicuries per square kilometer in 1960 and 1961, respectively. Thus, within the limits of experimental error, there was no significant change from 1960 to 1961; the apparent decreases observed at some of the stations are smaller than the probable error.

In considering the experimental values, the inherent errors in the sampling and analysis should be kept in mind (*10*). The estimated error for similar analyses carried out elsewhere was reported to be from 8 to 13 percent (*11*). Each of the samples reported here was analyzed in duplicate or more, with an average reproducibility of about 10 percent.

The decreases noted at Ft. St. John, Fredericton, and Montreal, however, appear to be real, as the duplicate analyses agreed well. Whether this is due to a deeper penetration of the strontium-90 into the soil or to a transformation into a less extractable form can be determined only by further comparative studies. Studies of the vertical penetration of strontium-90 with time, as reported by Hardy (*12, 13*) indicate that between 25 and 33 percent of the total strontium-90 was below the top two inches and less than 6 percent was below the 6-inch level.

In view of the correction necessary for the natural strontium content of the soil and the

TABLE 1.—STRONTIUM-90 IN CANADIAN SOIL, 1960 AND 1961

Latitude	Longitude	Location	Strontium-90 (nc/m²)	
			1960	1961
Calgary	51.1° N	114.0° W	16.3	14.3
Edmonton	53.6° N	113.5° W	20.0	17.3
Ft. Churchill	58.8° N	94.1° W	15.4	16.8
Ft. St. John	56.2° N	120.7° W	13.2	7.0
Ft. William	48.4° N	89.3° W	23.5	23.7
Fredericton	45.9° N	66.5° W	17.4	8.9
Goose Bay	53.3° N	60.4° W	15.9	12.3
Halifax	44.6° N	63.6° W	11.9	23.7
Inuvik	68.3° N	133.5° W	8.9	8.3
Kapuskasing	49.4° N	82.5° W	17.3	14.8
Montreal	45.5° N	73.7° W	17.9	7.9
Moosonee	51.3° N	80.6° W	17.5	22.5
Ottawa	45.4° N	75.7° W	16.2	17.0
Regina	50.4° N	104.7° W	14.0	18.9
Saskatoon	52.2° N	106.7° W	16.1	14.4
Torbay	47.5° N	52.8° W	—	29.1
Toronto	43.6° N	79.4° W	17.4	16.3
Vancouver	49.2° N	123.2° W	24.8	24.8
Whitehorse	60.7° N	135.1° W	8.3	8.2
Windsor	42.3° N	83.0° W	18.5	19.6
Winnipeg	49.9° N	97.2° W	16.8	17.5
Yellowknife	62.5° N	114.4° W	8.8	6.2
National average			15.8	15.4
Average below 60° N latitude			17.2	16.9

amount of strontium-90 extractable by 6N hydrochloric acid, the values presented here should be regarded as the lower limits of the total deposition.

Acknowledgments

The opportunity to observe and to discuss the soil analyses as carried out at the Health and Safety Laboratory of the U. S. Atomic Energy Commission, granted by Dr. J. H. Harley, Laboratory Director, is gratefully acknowledged. Much advice and assistance were received from G. H. Hamada and E. P. Hardy, Jr. on the details of the analysis.

Dr. L. T. Alexander, U. S. Department of Agriculture, selected four of the present sites and took the initial samples. The time, effort, and advice given by Dr. A. Leahey, Canada Department of Agriculture, in accompanying Dr. A. H. Booth of the Radiation Protection Division, during the selection of the sites and the collection of the 1960 samples are gratefully acknowledged.

The 1961 soil samples were taken by meteorologists of the Canada Department of Transport who are thanked for the cooperation and assistance given.

Discussions with R. F. Dever, U. S. Department of Agriculture, were very helpful in selecting the technique and equipment for sample preparation. He is also thanked for preparing the 1960 soils for analysis.

Finally, the 1961 samples were prepared for analysis in the Radiation Protection Division by M. E. Lescot and the analyses reported here were performed by G. P. Cox, G. P. Dumouchel, and R. Tuszynski.

REFERENCES

(*1*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW (RP-4)*, Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*2*) U. S. Atomic Energy Commission: *Environmental Contamination from Weapons Tests, HASL-42*:55, Office of Technical Services, Department of Commerce, Washington 25, D. C. (October 1958). price $3.50.

(*3*) United States Atomic Energy Commission: *Strontium Program Quarterly Summary Report, HASL-65*:98, Office of Technical Services, Department of Commerce, Washington 25, D. C. (May 29, 1959), price $3.50.

(*4*) United States Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL-88*:10, Office of Technical Services, Department of Commerce, Washington 25, D. C. (July 1, 1960), price $3.50.

(*5*) United States Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL-117*:142, Office of Technical Services, Department of Commerce, Washington 25, D. C. (December 30, 1961), price $3.50.

(*6*) Alexander, L. T.: *Collection of Soil Samples for Strontium-90 Assay, HASL-33*:21 (Rev.), Office of Technical Services, Department of Commerce, Washington 25, D. C. (1958).

(*7*) Hamada, G. H., and E. P. Hardy, Jr.: *A Procedure for the Acid Extraction and Analysis of Strontium-90 in Soil, HASL-33* (Rev.), Office of Technical Services, Department of Commerce, Washington 25, D. C. (1958).

(*8*) Hardy, E. P., Jr.: *Strontium-90 in Soil: Comparison of 1:1 HCl Extraction vs. Fusion, HASL-77*:44, Office of Technical Services, Department of Commerce, Washington 25, D. C. (January 1, 1960), price $3.50.

(*9*) Hardy, E. P., Jr.: *Comparison Between HCl Extraction and Fusion Method for Determining Strontium-90 in Soil, HASL-113*:97, Office of Technical Services, Department of Commerce, Washington 25, D. C. (July 1, 1961), price $2.50.

(*10*) Alexander, L. T., et al.: *Strontium-90 on the Earth's Surface, HASL-88*:195, Office of Technical Services, Department of Commerce, Washington 25, D. C. (July 1, 1960), price $3.50.

(*11*) Ong, L. D. Y., and R. Frankel: *Reproducibility of Analysis of 1960 Soils for Strontium-90, HASL-117*:217, Office of Technical Services, Department of Commerce, Washington 25, D. C. (December 30, 1961), price $3.50.

(*12*) Hardy, E. P., Jr.: *The Extent of Vertical Penetration of Strontium-90 in Soil With Time, HASL-84*:132, Office of Technical Services, Department of Commerce, Washington 25, D. C. (April 1, 1960), price $3.00.

(*13*) Hardy, E. P., Jr.: *Vertical Penetration of Strontium-90 in Sandy Soil from Alapaha, Georgia—1959 and 1960, HASL-113*:101, Office of Technical Services, Department of Commerce, Washington 25, D. C. (July 1, 1961), price $2.50.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U. S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Various summaries of the environmental radioactivity data for 22 AEC installations have appeared in *Radiological Health Data* since November 1960. Summaries follow for the Knolls Atomic Power Laboratory and the SIC Prototype Reactor Facility.

The measured concentration of a radionuclide in air and water may be compared with the Maximum Permissible Concentration (MPC) of that nuclide as recommended by the National Committee on Radiation Protection and Measurement (NCRP). For the environment near an AEC installation, the applicable values for continuous exposure given in the MPC's are one-tenth of the occupational MPC National Bureau of Standards "Handbook 69" (NCRP Report No. 22). The MPC values applicable to the reports that follow are given in table 1.

In these reports, nonspecific terms such as "total activity," "total alpha," and "gross beta" do not in themselves suggest any one MPC value. Often, when concentrations are low, a laboratory will assign an MPC value that is more restrictive than necessary. This avoids the more costly isotopic tests necessary to justify a less restrictive value.

TABLE 1.—SELECTED ENVIRONMENTAL MPC VALUES PERTAINING TO AEC INSTALLATION REPORTS IN THIS SUBSECTION

Line No.	Radioactive substance	Environmental MPC's	
		Water (μμc/liter)	Air (μμc/m³)
1	Cerium-144	10,000	200
2	Cesium-137	20,000	500
3	Iodine-131	3,000	300
4	Plutonium-239	5,000	0.06
5	Ruthenium-106	10,000	200
6	Strontium-89	10,000	1,000
7	Strontium-90	100	10
8	Zirconium-95	60,000	1,000
9	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present[1]	3,000	—
10	If Sr^{90}, Pb^{210}, Ra^{226}, Ra^{228} are not present[1]	600	—
11	If Ra^{226}, Ra^{228} are not present[1]	100	—
12	Mixture of unidentified nuclides	10	0.04
13	If α emitters and Ac^{227} are not present[1]	—	1.0
14	If α emitters and Pb^{210}, Ac^{227}, Ra^{228}, and Pu^{241} are not present[1]	—	10
15	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} are not present[1]	—	100

[1] "Not present" implies the concentration of the nuclide is small compared with its appropriate MPC. According to AEC regulation (Federal Register, Title 10, Part 20, August 9, 1961), a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than 1/10 and if th sum of these ratios for the group in question is equal to or le than 1/4.

KNOLLS ATOMIC POWER LABORATORY
Second Half 1961 and First Half 1962

General Electric Company
Schenectady, New York

The principal task of the Knolls Atomic Power Laboratory (KAPL) operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the Commission in the development of atomic power reactors for naval propulsion. This includes design, construction and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the West Milton site, located as shown in figure 1. The Knolls site occupies approximately 170 acres upon which are located administrative build-

TABLE 2.—AIRBORNE BETA ACTIVITY, KAPL
[Average concentrations in pc/m³]

Sampling locations	Third quarter 1961	Fourth quarter 1961	First quarter 1962	Second quarter 1962
Knolls site	1.3	5.2	4.7	4.3
West Milton site	2.2	4.4	7.0	6.8
Off-site	0.9	4.1	5.2	5.2

ings; chemistry, physics, metallurgical, engineering and radioactive materials laboratories; critical assembly buildings; machine shops; decontamination facilities; radioactive waste storage and processing facilites; and nuclear fuel storage and assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include the Triton and Bainbridge prototype reactors, equipment service building, fuel service building and waste treatment facility.

Air Monitoring

Environmental airborne radioactivity is measured at three locations on the Knolls site, four locations on the West Milton site and at the General Electric Company Research Laboratory, approximately one mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. The results of the airborne radioactivity analyses are given in table 2. Measurements of airborne radioactivity are made at least 48 hours after collection to allow the naturally occurring short-lived materials to decay.

Liquid Waste Monitoring

The dilution potential of the Mohawk River is utilized to a limited degree in the disposal of liquid radioactive wastes from the Knolls site. All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated acording to the concentration of fission products in the collection tanks and the flow of the river. A continuous proportional sample of the Knolls Site combined sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of weekly composite samples show that strontium-90 is the principal component to be considered in control. The amounts and the radioisotopic content of the combined sewer effluent discharged from the Knolls site have been summarized in table 3. A total of 11.3 curies of beta activity were discharged to the Mohawk River during the four quarters.

Mohawk river water is sampled continuously at the General Electric Company Powerhouse eight miles upstream from the Knolls site, and the Vischer Ferry Powerhouse approximately two miles downstream. Samples taken from the City of Cohoes pumping station approximately thirteen miles downstream show the same concentrations obtained for the Vischer Ferry samples shown in table 4.

Since the Glowegee Creek does not have a reliable dilution potential, the radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release to the creek. A total of 0.012 curies were discharged to Glowegee Creek during the four quarters at an average concentration of about 400 pc/liter.

Samples of the Glowegee Creek water are taken once a week at two locations, 150 feet above and 2,640 feet below the point where the

TABLE 3.—RADIONUCLIDE CONCENTRATIONS IN THE KNOLLS SITE WASTE EFFLUENT, KAPL

[Average concentrations in pc/liter]

Radionuclides	Third quarter 1961	Fourth quarter 1961	First half 1962
Ce^{144}-Pr^{144}	1,000	37,000	19,000
Sr^{89}	560	8,000	19,000
Sr^{90}	850	15,000	8,100
Cs^{137}	1,700	31,000	27,000
Gross beta	4,700	100,000	74,000

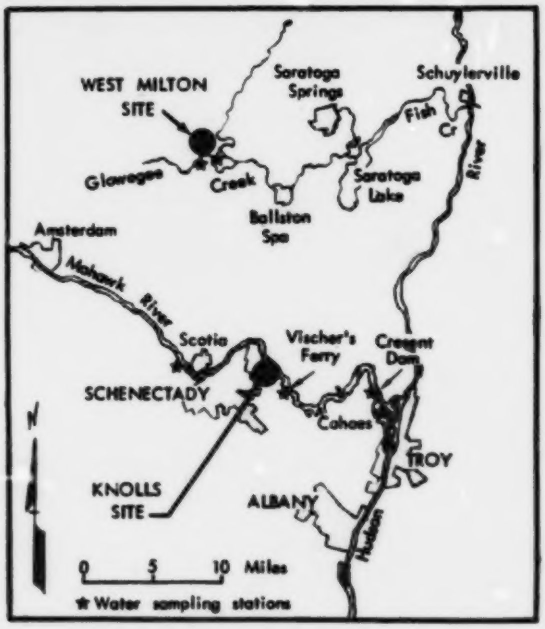

FIGURE 1.—ENVIRONMENTAL MONITORING LOCATIONS, KAPL, 1961-1962

TABLE 4.—GROSS BETA ACTIVITY IN STREAMS RECEIVING EFFLUENTS, KAPL

[Average concentrations in pc/liter]

Stream and location	Third quarter 1961	Fourth quarter 1961	First quarter 1962	Second quarter 1962
Mohawk River Knolls site:				
G. E. Powerhouse (upstream)	8	8	14	19
Vischer Ferry (downstream)	6	8	13	20
Glowegee Creek (West Milton site):				
Upstream	14	56	28	14
Downstream	8	38	25	11

West Milton site effluent enters the creek. Average concentrations found in samples c Glowegee Creek surface water are shown in table 4.

Previous coverage in *Radiological Health Data:*

Period	***Issue***
1959 and first quarter 1960	*December 1960*
Second quarter 1960	*January 1961*
Third and fourth quarters 1960	*September 1961*
First and second quarters 1961	*March 1962*

S1C PROTOTYPE REACTOR FACILITY
Second Half 1961 and First Half 1962

Combustion Engineering, Inc.
Windsor, Connecticut

The S1C Prototype is a land based nuclear submarine power plant facility, operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, at Windsor, Connecticut. The Prototype contains a pressurized water reactor power plant which is used for research, development and training.

Essentially all of the radioactive wastes originate from activation of minute amounts of impurities and corrosion products in the circulating water used as a reactor coolant. Ventilation air from the submarine hull and the supporting facility is continuously monitored at the exhaust stack. Liquid wastes are monitored before discharge to the Farmington River. Tables 5 and 6 give the average beta-

TABLE 5.— AIRBORNE BETA-GAMMA ACTIVITY, S1C

[Average concentrations in pc/m³]

Sampling location	Third quarter 1961	Fourth quarter 1961	First half 1962
Stack discharge	52	82	40
Downwind from stack	48	9.4	7

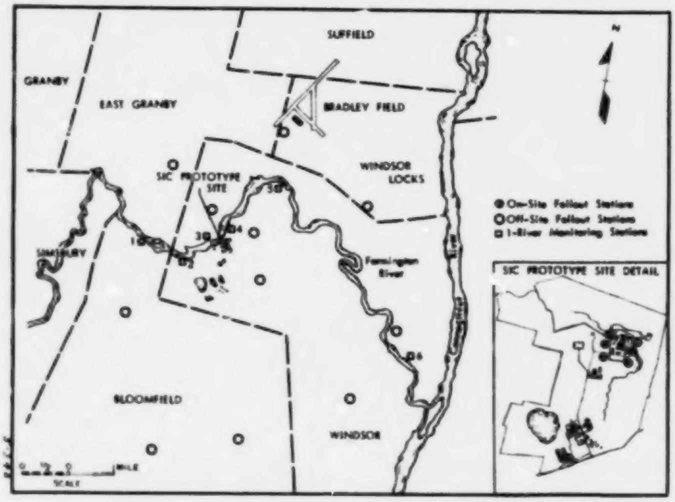
SUFFIELD
GRANBY
EAST GRANBY
BRADLEY FIELD
WINDSOR LOCKS
S1C PROTOTYPE SITE
SIMSBURY
Farmington River
BLOOMFIELD
WINDSOR
N
● On-Site Fallout Stations
○ Off-Site Fallout Stations
□ 1-River Monitoring Stations
S1C PROTOTYPE SITE DETAIL
1
2
3
4
5
6
0 ½ 1 MILE
SCALE

FIGURE 2.—ENVIRONMENTAL MONITORING LOCATIONS, S1C PROTOTYPE SITE, 1962

TABLE 6.—GROSS BETA RADIOACTIVITY IN LIQUID WASTES DISCHARGED INTO THE FARMINGTON RIVER, S1C

Period/values	Third quarter 1961	Fourth quarter 1961	First quarter 1962	Second quarter 1962
Total for quarter	3.13 mc	9.55 mc	30.36 mc	15.60 mc
Average concentration	2,000 pc/liter	3,100 pc/liter	8,200 pc/liter	7,300 pc/liter

gamma concentrations of airborne and liquid wastes before release to the environment.

Figure 2 shows the locations of six water sampling stations along the Farmington River and of 17 fallout monitoring stations. A more detailed description of S1C Prototype Reactor Facility and its control measures is available in the September 1961 issue of *Radiological Health Data*. Comparisions of the data for upstream and downstream samples appear in table 7. Comparisons of on-site and off-site fallout samples appear in table 8.

TABLE 7.—BETA-GAMMA ACTIVITY IN THE FARMINGTON RIVER, S1C

[Average concentrations in pc/liter]

Sampling locations (see figure 2)		Third quarter 1961	Fourth quarter 1961	First half 1962
Upstream:	1	1.5	66	37
	2	4.5	19	24
Outlet:	3	120	17	18
Downstream:	4	1.4	17	19
	5	2.7	22	13
	6	4.5	17	36

TABLE 8.—BETA ACTIVITY IN FALLOUT, S1C

[Average deposition in nc/m²/month]

Sampling locations	Third quarter 1961	Fourth quarter 1961	First half 1962
On site (6 stations)	3.29	37.2	33.0
Off site (11 stations)	3.68	40.4	34.7

Previous coverage in *Radiological Health Data:*

Period	*Issue*
First quarter 1960	*November 1960*
Second quarter 1960	*January 1961*
Third and fourth quarters 1960	*September 1961*
First and Second quarters 1961	*March 1962*

Reported Nuclear Detonations

June 1963

Four nuclear detonations in the United States during the month of June were announced by the Atomic Energy Commission. All tests were of low yield, conducted underground at the Nevada Test Site. Table 1 summarizes the detonations; the test numbers listed have been arbitrarily assigned by *RHD*.

On June 30, AEC announced evidence of possible recent U.S.S.R. nuclear tests of very low yield. The evidence being inconclusive, more definite conclusions cannot be made without further evidence and analysis.

TABLE 1.—SUMMARY OF NUCLEAR DETONATIONS REPORTED DURING JUNE 1963

Test number	Location	Date (1963)	Yield range	Type of test
104	Nevada Test Site	June 5	[a] Low	Underground
105	Nevada Test Site	June 6	Low	Underground
106	Nevada Test Site	June 14	Low	Underground
107	Nevada Test Site	June 25	Low	Underground

[a] Low yield range has been announced as less than 20 kilotons yield.

RADIOLOGICAL HEALTH DATA

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Early indications of possible fission product activity fluctuations in various phases of the environment are being secured through the continuous surveillance of gross beta activity in air and precipitation. The information obtained through this form of surveillance does not by itself permit evaluation of biological effects due to fallout, but it does form the basis for an alerting system and can be used as a guide for determining when and where more extensive monitoring of radioactivity in food, milk, and water is desirable.

In this section, gross beta concentrations for April 1963 are presented in reports from the Radiation Surveillance Network and the Canadian Radioactive Fallout Study Program. Network intercalibration factors, determined by Lockhart and Patterson (*1*), were used in constructing the isogram map (figure 4), which presents data on Canadian and U.S. gross beta radioactivity in air for April. To adjust the data from the two networks to a common baseline, the U.S. data were multiplied by a factor of 1.54, the U.S.-Canadian intercalibration factor suggested by the NRL study.

REFERENCE

(*1*) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850,* Washington, D. C. (November 13, 1962); abstracted in *Radiological Health Data,* December 1962.

RADIATION SURVEILLANCE NETWORK
April 1963

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) comprises 72 sampling stations distributed throughout the United States (see figure 1). Most of these stations are manned by State health department personnel.

Air

Daily 24-hour samples are collected on a 4-inch diameter, carbon-loaded cellulose dust filter in a high-volume air sampler. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}–Y^{90} source of known activity. This determination is usually made about 5 hours after the end of collection to eliminate interference from naturally occurring radon daughters. The Network's station operators report their field estimates daily by telephone to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. From this information, a daily national report is prepared.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville,

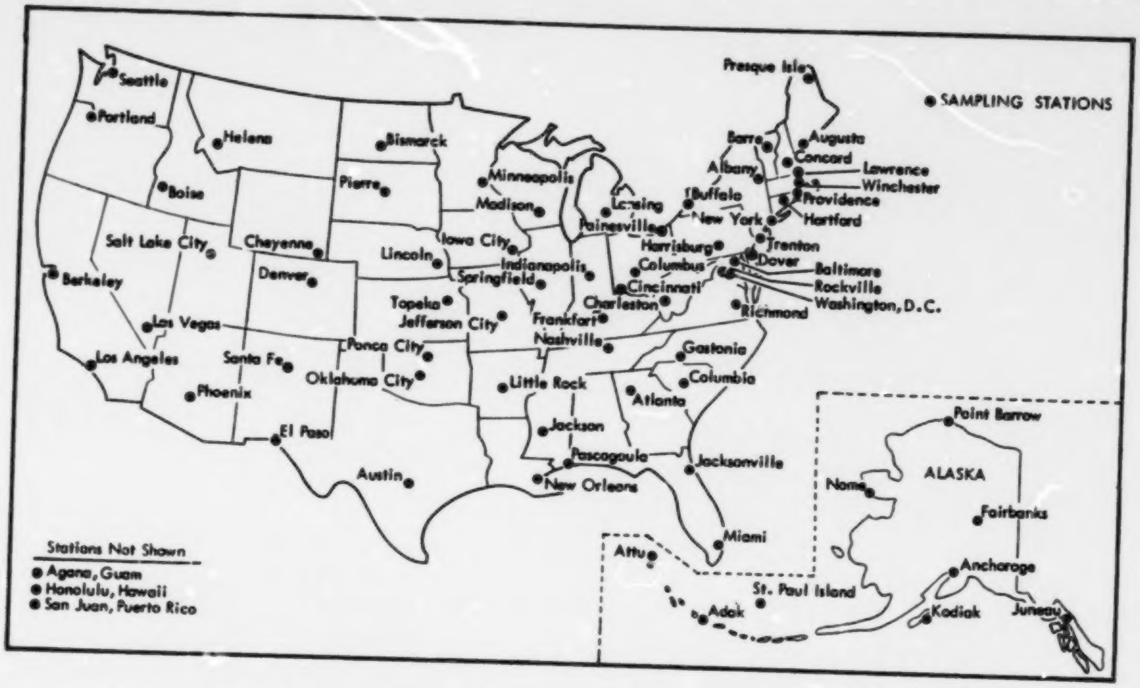
● SAMPLING STATIONS
Seattle
Portland
Helena
Boise
Berkeley
Salt Lake City
Las Vegas
Los Angeles
Phoenix
Cheyenne
Denver
Santa Fe
El Paso
Bismarck
Pierre
Lincoln
Topeka
Jefferson City
Ponca City
Oklahoma City
Austin
Minneapolis
Madison
Iowa City
Springfield
Indianapolis
Little Rock
Jackson
New Orleans
Pascagoula
Lansing
Painesville
Columbus
Cincinnati
Charleston
Frankfort
Nashville
Atlanta
Gastonia
Columbia
Jacksonville
Miami
Harrisburg
Buffalo
New York
Albany
Barre
Presque Isle
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Richmond
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Juneau
Kodiak
St. Paul Island
Adak
Attu
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, APRIL 1963

Maryland, for a more refined measurement with a thin-window, gas-flow proportional counter, calibrated with a 40,000-pc Sr^{90}–Y^{90} standard. Each filter is counted at least 3 days after the end of the sampling period and re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally occurring radon and thoron daughters. From the two counts, which are separated by a 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula: $AT^{1.2}$ = constant (*1*)*. The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*2*).

The average fission-product beta concentrations in surface air during April 1963, as determined by laboratory analysis and extrapolated to the time of collection, are given in table 1. These data (adjusted by the intercalibration factor, 1.54), together with corresponding Canadian data, are represented by isogram lines in figure 4 to show the distribution of fission product activity over most of North America.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis using funnels with collection areas of 0.4 square meters. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples, including extrapolation to the time of collection. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml. (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made. April 1963 averages of gross beta activity in precipitation, expressed in picocuries per liter (pc/liter) and nanocuries per square meter (nc/m²), are presented in table 2.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in *RHD*, July 1961. The profiles of 7 stations, updated through April 1963, are shown in figure 2.

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* In this expression, A is the activity and T is the time after fission product formation.

TABLE 1.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, RSN, APRIL 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average[1]
Alaska:	Adak	30	10	0.13	3.6
	Anchorage	30	8.5	0.37	3.7
	Attu	30	12	0.39	5.6
	Fairbanks	[illegible]	7.4	0.71	4.2
	Juneau	25	9.9	0.42	4.1
	Kodiak	27	13	0.22	3.9
	Nome	23	3.1	0.25	1.3
	Point Barrow	19	7.2	0.75	4.2
	St. Paul Island	25	7.9	0.25	4.2
Ariz:	Phoenix	29	30	5.7	13
Ark:	Little Rock	29	17	5.4	11
Calif:	Berkeley	28	7.7	0.65	3.9
	Los Angeles	21	14	3.5	6.7
Colo:	Denver	26	22	6.0	13
Conn:	Hartford	27	12	0.80	6.9
Del:	Dover	19	24	2.3	12
D.C:	Washington	30	14	1.5	7.6
Fla:	Jacksonville	29	17	1.9	9.3
	Miami	28	16	4.2	9.9
Ga:	Atlanta	25	13	1.4	8.0
Guam:	Agana	19	7.1	<0.10	2.5
Hawaii:	Honolulu	29	9.4	0.86	4.1
Idaho:	Boise	28	18	1.2	8.3
Ill:	Springfield	28	12	0.81	6.4
Ind:	Indianapolis	29	14	0.79	7.5
Iowa:	Iowa City	30	12	0.99	5.8
Kans:	Topeka	25	15	2.8	8.4
Ky:	Frankfort	30	16	1.5	8.1
La:	New Orleans	29	12	0.69	7.6
Maine:	Augusta	30	14	0.91	6.5
	Presque Isle	30	8.4	0.17	4.3
Md:	Baltimore	21	12	1.6	7.7
	Rockville	17	14	1.3	8.6
Mass:	Lawrence	29	11	<0.10	5.9
	Winchester	28	18	<0.10	9.4
Mich:	Lansing	28	17	0.97	7.9
Minn:	Minneapolis	29	11	0.65	6.0
Miss:	Jackson	30	14	2.2	8.7
	Pascagoula	21	16	3.2	10
Mo:	Jefferson City	29	17	1.3	7.5
Mont:	Helena	28	13	2.0	6.3
Nebr:	Lincoln	17	13	2.3	7.4
Nev:	Las Vegas	22	31	4.9	14
N.H:	Concord	21	15	0.14	7.9
N.J:	Trenton	30	16	0.81	7.8
N. Mex:	Santa Fe	27	19	3.3	9.9
N.Y:	Albany	28	11	0.43	6.2
	Buffalo	26	14	0.97	7.6
	New York	15	13	0.32	6.4
N.C:	Gastonia	29	15	4.8	8.8
N. Dak:	Bismarck	30	11	1.7	6.1
Ohio:	Cincinnati	20	12	0.92	7.2
	Columbus	29	18	1.1	8.6
	Painesville	30	14	1.1	8.8
Okla:	Oklahoma City	29	15	2.5	7.8
	Ponca City	30	9.8	2.1	5.5
Ore:	Portland	30	14	2.3	6.1
Pa:	Harrisburg	21	16	1.7	7.8
P.R:	San Juan	29	18	1.2	5.6
R.I:	Providence	28	15	0.29	7.2
S.C:	Columbia	29	15	3.1	7.5
S. Dak:	Pierre	30	14	1.1	5.8
Tenn:	Nashville	30	17	3.4	11
Tex:	Austin	30	21	1.3	8.6
	El Paso	30	23	4.5	12
Utah:	Salt Lake City	29	16	0.25	8.8
Vt:	Barre	30	17	0.18	6.7
Va:	Richmond	29	10	1.9	6.4
Wash:	Seattle	30	6.6	0.85	2.9
W.Va:	Charleston	27	14	1.5	7.3
Wis:	Madison	29	17	0.82	8.2
Wyo:	Cheyenne	30	22	2.6	10
Network average					7.3

[1] Averages are weighted by length of sampling time.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, APRIL 1963

Station location		Average concentration (pc/liter)	Total deposition[a] (nc/m²)
Alaska:	Anchorage	2,200	49
	Fairbanks	2,000	13
	Juneau		
Ariz:	Phoenix	[b]—	[b]—
Ark:	Little Rock	970	87
Calif:	Berkeley	770	100
	Los Angeles	1,900	91
Colo:	Denver	[b]—	[b]—
Conn:	Hartford	3,200	49
D.C:	Washington	7,900	180
Fla:	Jacksonville	2,000	29
	Miami	[b]—	[b]—
Ga:	Atlanta	640	20
Hawaii:	Honolulu	[b]—	[b]—
Idaho:	Boise	4,000	270
Ill:	Springfield	2,000	20
Ind:	Indianapolis	1,900	170
Iowa:	Iowa City	3,700	230
Kans:	Topeka	4,300	72
Ky:	Frankfort	1,700	61
La:	New Orleans	2,500	69
Maine:	Augusta	2,300	120
	Presque Isle	2,000	66
Md:	Baltimore	2,900	34
Mass:	Lawrence	1,900	40
	Winchester	3,500	78
Mich:	Lansing	4,400	180
Minn:	Minneapolis	2,300	130
Miss.	Jackson	3,500	35
Mo:	Jefferson City	2,200	93
Mont:	Helena	3,300	104
Nebr:	Lincoln	8,000	57
Nev:	Las Vegas	[b]—	[b]—
N.J:	Trenton	3,300	10
N. Mex:	Santa Fe	3,700	28
N.Y:	Albany	[c]	[c]
	Buffalo	[b]—	[b]—
N.C:	Gastonia	900	64
N. Dak:	Bismarck	4,300	200
Ohio:	Columbus	3,000	330
	Painesville	3,400	200
Okla:	Oklahoma City	1,300	43
	Ponca City	1,300	22
Ore:	Portland	1,200	92
Pa:	Harrisburg	4,300	47
P.R:	San Juan	670	34
R.I:	Providence	4,500	93
S.C:	Columbia	1,700	150
S. Dak:	Pierre	2,100	83
Tenn:	Nashville	1,900	110
Tex:	Austin	1,500	79
	El Paso	[b]—	[b]—
Utah:	Salt Lake City	3,600	390
Vt:	Barre	2,700	170
Va:	Richmond	3,400	29
Wash	Seattle	2,900	130
W.Va:	Charleston	4,800	94
Wisc:	Madison	3,200	130
Wyo:	Cheyenne	6,000	170

[a] Precipitation (mm) = $\frac{\text{nc/m}^2}{\text{pc/liter}} \times 1{,}000$.

[b] Dash indicates no evaporated sample received.

[c] No data received.

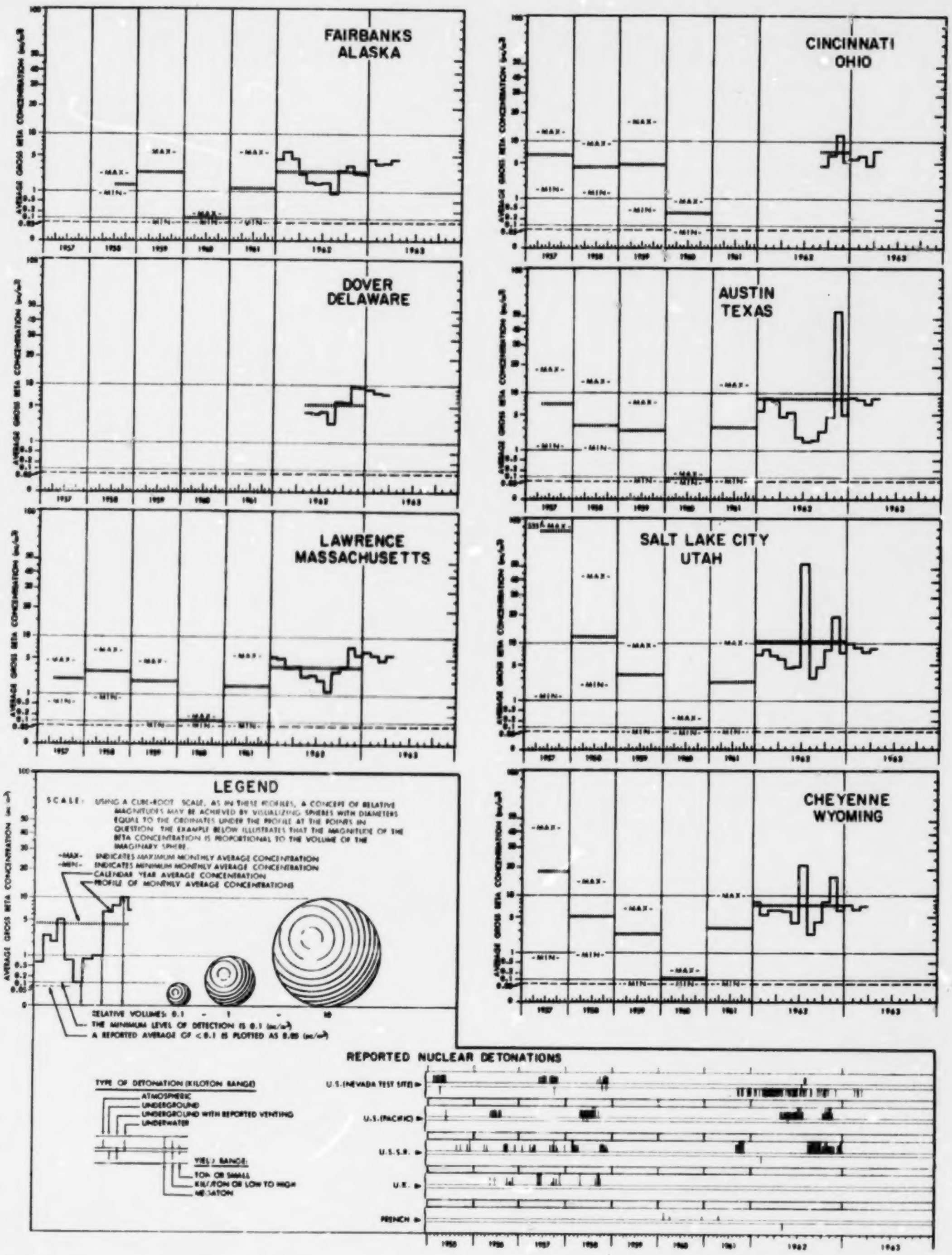

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1957-APRIL 1963

REFERENCES

(1) Way, K., and E. P. Wigner: The Rate of Decay of Fission Products, *Physics Review*, 73:1318–30 (June 1948).

(2) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service. Washington 25, D. C. (Distribution by official request).

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[1] See reference (1) on page 1-1.

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CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM
April 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four RFSP collection stations are located at airports (see figure 3) where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

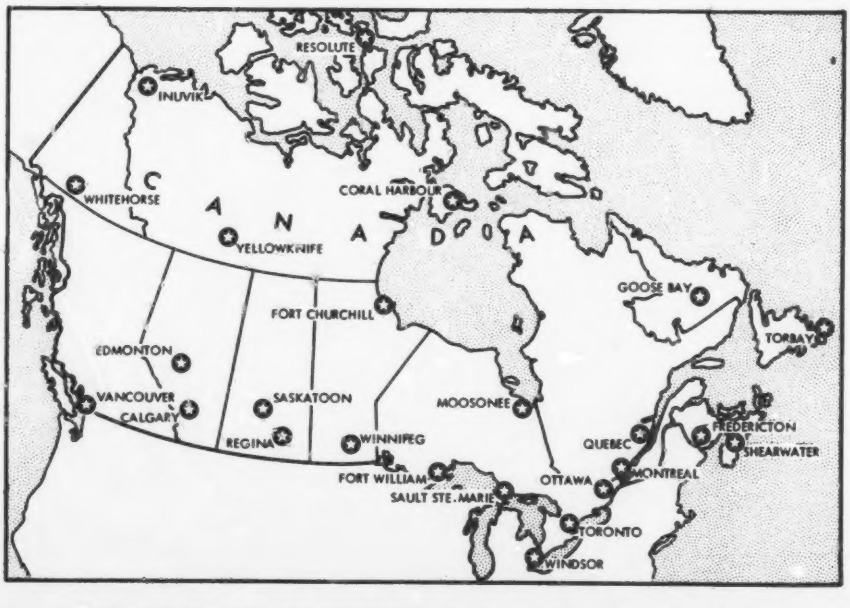
Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow, Geiger-Mueller flow counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, RFSP, APRIL 1963

[Concentrations in pc/m^3]

Station	Number of samples	Maximum	Minimum	Average
Calgary	30	31.0	3.6	13.8
Coral Harbour	30	18.3	3.6	8.9
Edmonton	30	27.0	3.9	11.8
Ft. Churchill	29	11.1	2.5	7.3
Ft. William	30	25.0	1.0	10.6
Fredericton	30	25.0	0.7	9.2
Goose Bay	29	22.5	1.5	9.5
Inuvik	30	23.5	4.7	8.7
Montreal	30	26.5	0.7	12.8
Moosonee	30	23.0	1.5	11.0
Ottawa	30	22.0	2.9	12.6
Quebec City	30	29.0	0.6	10.8
Regina	30	20.0	3.2	12.4
Resolute	30	17.9	5.0	9.6
Saskatoon	28	26.5	4.1	14.3
Sault St. Marie	30	20.5	1.9	12.1
Shearwater	30	25.0	0.3	8.9
Torbay	28	16.8	0.2	5.0
Toronto	30	26.5	2.0	11.5
Vancouver	30	19.8	1.7	7.3
Whitehorse	30	16.8	0.7	9.3
Windsor	30	25.0	2.4	14.0
Winnipeg	30	28.0	0.9	11.7
Yellowknife	30	15.5	3.8	9.5
Average				10.5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INUVIK
C A N A D A
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
TORBAY
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
SHEARWATER
FORT WILLIAM
OTTAWA
MONTREAL
SAULT STE. MARIE
TORONTO
WINDSOR

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS, APRIL 1963

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made on each filter to permit correction for the presence of natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for April 1963 are given in table 3 and presented in conjunction with U.S. adjusted air data by the isogram map (figure 4).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample, and sent to the laboratory. April precipitation data for Canada, including some radiochemical analyses, are shown in table 4.

REFERENCES

(1) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW-RP-3*, Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4*, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) Mar, P. G.: *Annual Report for 1961 on the Radioactive Fallout Study Program CNHW-RP-5*, Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) Beale, J. and J. Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program, RPD-11*, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RPD-21*, Department of National Health and Welfare, Ottawa, Canada (August 1962).

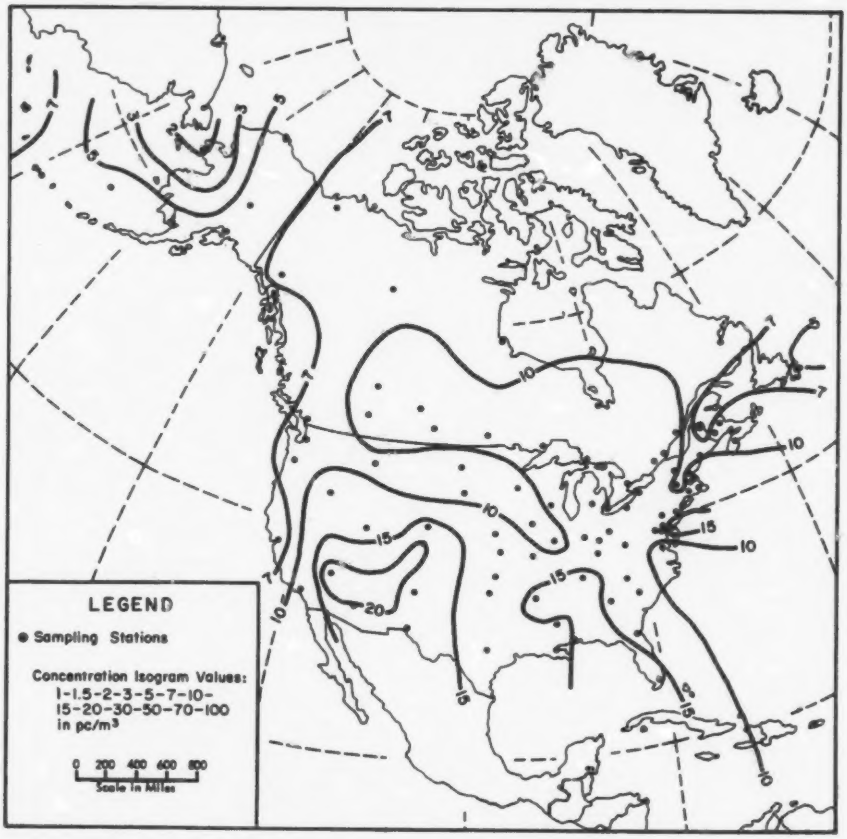

FIGURE 4.—AIRBORNE GROSS BETA CONCENTRATION ISOGRAM VALUES FOR CANADA AND THE U.S., APRIL 1963

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, RFSP, APRIL 1963

Station	Total beta activity		Deposition of specific radionuclides for selected samples[a] (nc/m²)				
	pc/liter	nc/m²	Sr^{89}	$^{b}Sr^{90}$	$^{b}Zr^{95}$	$^{b}Cs^{137}$	Ba^{140}
Calgary	6831	130.0	9.7	1.10	17.3	1.93	0.15
Coral Harbour	5513	47.6					
Edmonton	4240	88.2					
Fredericton	3007	205.2					
Ft. Churchill	2900	30.2					
Ft. William	4215	271.7					
Goose Bay	2597	80.4					
Inuvik	1858	28.3					
Montreal	4093	346.8	24.2	2.98	45.7	5.43	0.37
Moosonee	4457	162.9					
Ottawa	3430	233.1					
Quebec	3567	238.1					
Regina	6011	106.8					
Resolute	2679	68.0					
Saskatoon	4911	152.0					
Sault Ste. Marie	3565	123.9					
Shearwater	2122	232.1	18.0	1.98	24.8	4.86	0.24
Torbay	1455	219.7					
Toronto	4452	241.8					
Vancouver	3476	252.2	19.6	2.54	31.5	4.09	0.29
Whitehorse	[c]	42.3					
Windsor	3224	269.2					
Winnipeg	3269	295.3	20.9	2.84	45.5	5.20	0.31
Yellowknife	3895	56.5					
Average	3946	136.4					

[a] All values corrected for decay back to end of collection month.

[b] Values for strontium-90, cesium-137, and zirconium-95 do not include the activities of their daughter isotopes, yttrium-90, barium-137, and niobium-95.

[c] Trace precipitation.

Fission Product Gamma Activity in Airborne Particulates

In a recent proposal (*1*) submitted by the World Meteorological Organization (WMO), after consultation with the United Nations Scientific Committee on the Effects of Atomic Radiation, the concept of air monitoring for fission products by gamma rather than beta counting was advanced. The method involving the simultaneous measurement of total gamma and of gamma-over-1-Mev has been adopted for use with the 80th Meridian Network (*2*).

REFERENCES

(*1*) United Nations General Assembly, Seventeenth Session: *Agenda Item 30, Report of the United Nations Scientific Committee on the Effects of Atomic Radiation—Report of the World Meteorological Organization on the Implementation of General Assembly Resolution 1629* (XVI), New York, October 8, 1962.

(*2*) Collins, W. R., Jr.: Fission Product Gamma Activity in Airborne Particulates, The 80th Meridian Network, January 1963, *Radiological Health Data*, *4*:342-6, Superintendent of Documents, Government Printing Office, Washington 25, D. C. (July 1963).

THE 80TH MERIDIAN NETWORK
February 1963

Health and Safety Laboratory
Atomic Energy Commission

This report covers the data available for gamma activity measurements performed on ground-level air filter samples from the 80th Meridian Network for February 1963. Sampling locations of the Network are shown in figure 1. Through the end of February, all stations operated as previously described by the Naval Research Laboratory,[1]

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[1] Monthly gross beta averages and profiles of the 80th Meridian Network, Naval Research Laboratory, covering the period from November 1959 through December 1962, were reported monthly in *Radiological Health Data*—April 1960–April 1963. Results of the radiochemical analyses of air filters for the calendar years 1960 and 1961 were presented in *RHD*—March 1962 and February 1963, respectively.

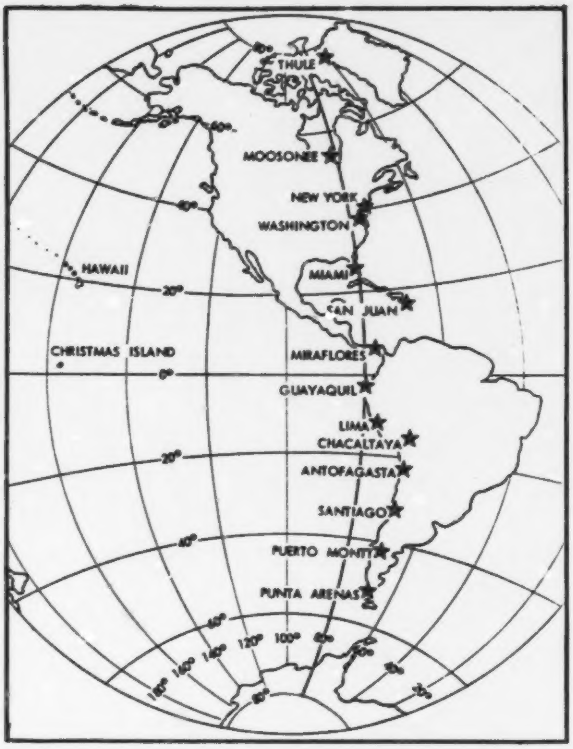

FIGURE 1—ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (WEST)

sampling about 1200 cubic meters of air per day on 8-inch cellulose asbestos (type 6) filter papers. Samples were changed, when possible, on the 1st, 8th, 15th, and 22nd of the month and forwarded to the Health and Safety Laboratory for gamma radiometric and radiochemical analyses.

Each sample received was counted approximately two weeks after the midpoint of the sampling period on an 8 x 4 inch sodium iodide (thallium) crystal, obtaining both total gamma activity and the fraction of the gamma activity with energies above 1.0 Mev. The results, in terms of gamma photons per minute per cubic meter, are listed in table 1. The monthly averages are illustrated in figure 2 as an activity-latitude profile. Total beta activity estimates, obtained by the method described in the January 1963 report[2] are also listed in table 1.

The ratio of hard gamma (over 1 Mev) to total gamma gives some indication of age of fission products. Based on a sample of irradiated U^{235}, fission products having an average age greater than four months show a fairly constant gamma ratio of 0.011, and younger fission products show a higher ratio.[2] The gamma ratios shown in table 1 show little difference between Northern and Southern Hemispheres.

TABLE 1.—ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, FEBRUARY 1963

Sampling station	Sampling period (dates—noon to noon)	Total/gamma activity (photons/min/m³)		Ratio: γ > 1 Mev / Total γ	Estimated total beta activity (pc/m³)
		Filter	Average for month		
Thule	2/1-8	6.69		0.020	4.5
	2/8-15	8.49		0.020	5.7
	2/15-22	12.5		0.020	8.5
	2/22-3/1	14.2	10.5	0.017	9.6
Moosonee	2/1-8	8.47		0.030	5.7
	2/22-3/1	8.29	8.41	0.021	5.6
New York [a]	—	—	—	—	—
Washington	2/1-8	15.7		0.026	10.6
	2/8-15	7.66		0.019	5.2
	2/15-22	11.0		0.028	7.4
	2/22-3/1	11.8	11.5	0.016	8.0
Miami	2/1-8	19.5		0.020	13.1
	2/8-15	12.0		0.022	8.1
	2/15-22	18.4		0.022	12.4
	2/22-3/1	14.9	15.9	0.022	10.1
Mauna Loa	2/1-8	4.60		0.023	3.1
	2/8-15	2.50		0.024	1.7
	2/15-22	6.35		0.024	4.3
	2/22-3/1	6.44	4.97	0.023	4.3
San Juan	2/1-8	4.55		0.022	3.1
	2/8-15	5.98		0.023	4.0
	2/15-22	6.86		0.023	4.6
	2/22-3/1	4.66	5.48	0.022	3.1
Miraflores	2/1-8	4.63		0.024	3.1
	2/8-15	3.55		0.025	2.4
	2/15-22	4.18		0.024	2.8
	2/22-3/1	5.66	4.52	0.029	3.8
Guayaquil [b]	—	—	—	—	—
Lima [b]	—	—	—	—	—
Chacaltaya	2/1-8	0.985		0.014	0.67
Antofagasta	2/1-8	0.578		0.019	0.39
	2/8-15	0.715		0.013	0.48
	2/15-22	0.569		0.019	0.38
	2/22-3/1	0.340	0.551	0.022	0.23
Santiago	2/1-8	0.392		0.020	0.26
	2/8-15	0.438		0.018	0.30
	2/15-22	0.501		0.014	0.34
	2/22-3/1	0.358	0.422	0.027	0.24
Puerto Montt	2/1-8	0.261		0.012	0.18
	2/8-15	0.145		0.023	0.10
	2/15-22	0.285		0.015	0.19
	2/22-3/1	0.118	0.204	0.020	0.08
Punta Arenas	2/1-8	0.306		0.011	0.21
	2/8-15	0.216		0.023	0.15
	2/15-22	0.172	0.239	0.021	0.12

[a] Scheduled to begin operation in March 1963.
[b] Data not available.

In general, the total activity estimates show little variation in either the Northern or Southern Hemispheres from the January 1963 estimates or values previously reported by the Naval Research Laboratory during the last quarter of 1962; the surface air activity in the Southern Hemisphere continues to be less than a tenth that of the Northern Hemisphere.

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[2] See reference (2) above.

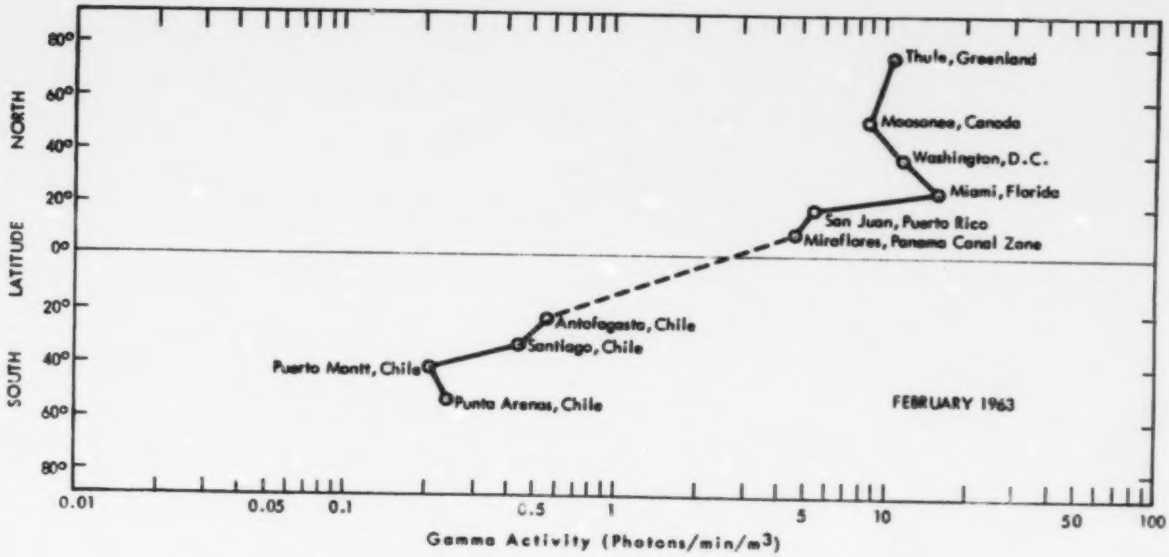

FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, FEBRUARY, 1963

Monthly Deposition of Various Radionuclides

For the purposes of this section, fallout is defined as any radioactive material deposited on the earth's surface. Fallout is composed of two fractions: that deposited by the settling of particulates, often termed dry fallout; and that contained in precipitation, sometimes called wet fallout or rainout. Normally, fallout is expressed in terms of the activity of selected radionuclides deposited on a unit surface area during a given period of time.

FALLOUT IN THE UNITED STATES AND OTHER AREAS*

January 1962–June 1962

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates are determined by the Atomic Energy Commission's Health and Safety Laboratory (HASL) for 40 sites in the United States and 93 locations in other countries. HASL data from 37 of the U.S. stations and 8 other selected points in the Western Hemisphere (see figure 1) covering the period from January 1961 through June 1962 are summarized below.

Methods of Collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout for a period of one month are collected in stainless steel pots with exposed areas of 0.076m². At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with exposed area of 0.072m², attached to an ion-exchange column. After a one-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis.

A statistical analysis comparing results obtained using the two types of collectors has been published (*1*). This study was based on strontium-90 measurements of duplicate samples from five locations in the United States where both pot and column samples were collected. It was found that at the 95 percent confidence level there was no significant difference in the strontium-90 measurements obtained from pot and column samples.

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* The data in this article were extracted from *Fallout Program Quarterly Summary Report, HASL-135*:2-144 (April 1, 1963).

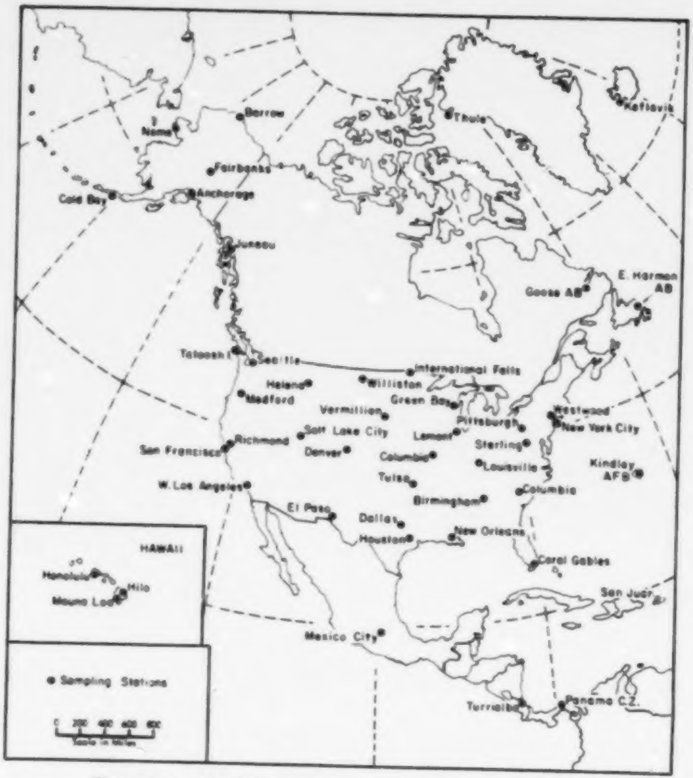
Barrow
Nome
Fairbanks
Cold Bay
Anchorage
Juneau
Thule
Keflavik
Goose AB
E. Harmon AB
Tatoosh I.
Seattle
International Falls
Helena
Williston
Medford
Vermillion
Green Bay
Westwood
Pittsburgh
New York City
Salt Lake City
Lemont
San Francisco
Richmond
Denver
Sterling
Columbia
Louisville
Kindley AFB
W. Los Angeles
Tulsa
Columbia
Birmingham
El Paso
Dallas
New Orleans
Houston
Coral Gables
San Juan
HAWAII
Honolulu
Hilo
Mauna Loa
Mexico City
Sampling Stations
Turrialba
Panama C.Z.
0 200 400 600 800
Scale in Miles

FIGURE 1—HASL FALLOUT SAMPLING LOCATIONS

Strontium-90

All of the HASL fallout samples—both pot and column—were assayed for strontium-90 and the ratio of strontium-89 to strontium-90. The strontium-90 data are given in table 1 for the 48 selected stations. Where duplicate samples were collected, the average values are given.

TABLE 1.—MONTHLY STRONTIUM-90 FALLOUT
[Deposition in nc/m²]

Sampling location and type of collection		1962					
		January	February	March	April	May	June
Ala:	Birmingham (pot)	1.74	1.11	1.44	3.20	0.66	0.70
Alaska:	Anchorage (col)	0.10	0.25	0.22	0.35	0.38	0.83
	Barrow (col)	<0.01	<0.01	<0.01	0.01	0.77	0.46
	Cold Bay (col)	—	—	—	0.26	1.52	1.00
	Fairbanks (col)	0.08	0.22	0.18	0.08	0.22	0.90
	Juneau (col)	0.40	0.06	0.51	0.05	0.52	1.39
	Nome (col)	0.42	—	0.47	0.47	0.14	0.26
Calif:	W. Los Angeles (pot)	0.46	3.29	0.53	0.07	0.07	0.05
	Richmond (pot)	0.32	1.64	0.27	0.29	0.02	0.04
	Richmond (col)	0.27	1.24	0.86	0.27	0.02	0.05
	San Francisco (col)	0.29	1.34	0.48	0.21	0.05	0.03
Colo:	Denver (col)	0.06	—	0.14	0.98	0.78	1.37
Fla:	Coral Gables (pot)	0.24	0.24	0.62	1.35	0.37	0.80
Hawaii:	Hilo (col)	0.31	1.43	2.20	0.32	3.38	0.84
	Mauna Loa (col)	0.16	0.02	0.41	0.41	0.57	0.07
	Oahu (pot)	0.36	1.07	1.37	0.22	0.98	0.56
Ill:	Lemont (pot)	0.60	0.57	0.02	0.63	2.69	0.64
Ky:	Louisville (pot)	0.79	0.92	1.16	0.51	1.52	1.55
La:	New Orleans (col)	0.64	0.24	0.58	1.11	0.47	0.91
Minn:	International Falls (col)	0.07	0.15	0.28	0.05	3.46	2.06
Mo:	Columbia (col)	2.62	0.88	1.10	1.07	2.25	0.69

TABLE 1.—MONTHLY STRONTIUM-90 FALLOUT—Continued

[Deposition in nc/m²]

Sampling location and type of collection			1962					
			January	February	March	April	May	June
Mont:	Helena	(col)	0.04	0.14	0.16	0.06	1.66	1.53
N.J.:	Westwood	(pot)	0.57	1.18	0.81	2.12	1.02	1.85
	Westwood	(col)	0.53	1.11	0.72	1.89	1.15	2.09
N.Y:	New York	(pot)	0.36	1.22	0.56	0.85	0.88	1.49
N. Dak:	Williston	(col)	0.03	0.09	0.18	0.28	1.89	1.11
Okla:	Tulsa	(pot)	1.35	0.78				
Ore:	Medford	(col)	0.19	0.18	0.39	0.29	0.56	0.12
Pa:	Pittsburgh	(pot)	0.51	0.80	0.87	1.49	1.36	0.60
	Pittsburgh	(col)	0.56	0.80	0.92	1.65	1.55	0.67
S.C:	Columbia	(col)	0.72	0.83	1.57	0.09	1.51	0.87
S. Dak:	Vermillion	(pot)	0.06	0.48	1.27	1.95	6.00	1.56
Tex:	Dallas	(col)	0.32	0.40	0.98	2.87	0.36	1.38
	El Paso	(col)	0.39	0.15	0.11	0.27	0.03	—
	Houston	(pot)	0.31	0.26	0.40	1.86	0.17	1.59
	Houston	(col)	0.37	0.19	0.33	1.56	0.16	0.82
Va:	Sterling	(col)	0.33	0.54	0.62	1.05	0.93	0.95
Utah:	Salt Lake City	(pot)	0.45	1.74	2.15	2.61	4.12	0.13
Wash:	Seattle	(pot)	0.59	0.60	1.62	0.91	1.02	0.34
	Tatoosh I.	(col)	0.82	0.67	1.35	1.71	0.76	0.34
Wis:	Green Bay	(col)	0.10	0.66	0.72	1.01	0.21	1.82
Greenland:	Thule	(col)	<0.01	<0.01	<0.01	0.04	0.05	<0.01
Iceland:	Keflavik	(col)	0.60	0.20	0.27	0.91	0.55	0.67
Newfoundland:	Goose A.B.	(col)	0.05	0.14	0.29	0.02	0.96	1.09
	E. Harmon A.B.	(col)	0.33	0.23	0.17	0.83	0.94	1.48
Bermuda:	Kindley A.F.B.	(col)	0.40	0.42	2.71	1.07	0.84	0.43
Puerto Rico:	San Juan	(col)	0.59	0.39	—	1.37	1.01	0.61
Mexico:	Mexico City	(col)	<0.01	0.01	<0.01	1.05	0.23	0.31
Costa Rica:	Turrialba	(col)	0.32	0.15	0.16	0.47	0.44	0.14
Panama Canal Zone		(col)	0.16	<0.01	0.04	—	—	0.73

TABLE 2.—RADIOCHEMICAL ANALYSES OF POT FALLOUT SAMPLES

Location and analyses	1962					
	January	February	March	April	May	June
California, Richmond						
Precipitation (mm)	30	226	22	8	dry	dry
Sr^{89}/Sr^{90} ratio	38	26	21	10	7.6	4.6
Zr^{95} (nc/m²)	[a]—	20.1	10.8	—	0.01	0.93
Cs^{137} (nc/m²)	0.46	2.2	0.50	0.50	0.04	0.01
Ba^{140} (nc/m²)	2.83	[b]ND	—	—	—	—
New Jersey, Westwood						
Precipitation (mm)	75	113	116	86	32	160
Sr^{89}/Sr^{90} ratio	46	30	18	12	10	5.4
Zr^{95} (nc/m²)	41	51	19	32	15	22
Cs^{137} (nc/m²)	1.05	1.83	1.19	3.20	1.46	3.25
Ba^{140} (nc/m²)	3.9	2.40	—	—	—	—
Pennsylvania, Pittsburgh						
Precipitation (mm)	52	90	77	116	66	41
Sr^{89}/Sr^{90} ratio	48	28	20	14	9.6	6.4
Zr^{95} (nc/m²)	22.3	20.2	22.4	32.2	27.0	3.8
Cs^{137} (nc/m²)	—	—	1.88	3.70	2.68	1.08
Ba^{140} (nc/m²)	3.8	1.4	—	—	—	—
Texas, Houston						
Precipitation (mm)	32	15	15	122	29	188
Sr^{89}/Sr^{90} ratio	58	26	18	13	29	8.6
Zr^{95} (nc/m²)	8.1	6.6	31	51	11	80
Cs^{137} (nc/m²)	—	—	—	—	—	—
Ba^{140} (nc/m²)	8.2	1.1	1.1	—	—	—

[a] Dash indicates sample not analyzed.
[b] Not detected.

Other Radionuclides

Laboratories at Richmond, California; Westwood, New Jersey; Pittsburgh, Pennsylvania; and Houston, Texas, have analyzed duplicate monthly collections for various radionuclides. The monthly deposition rates for Zr^{95}, Cs^{137}, and Ba^{140}, as well as the Sr^{89}/Sr^{90} ratio and precipitation depth, are presented in table 2. The strontium-90 values for these stations are included in table 1.

REFERENCE

(*1*) Ong, L. D. Y., Homogeneity Between Pot and Ion Exchange Columns Strontium-90 Measurements, *Fallout Program Quarterly Summary Report, HASL 135*:256-69, Office of Technical Services, Department of Commerce, Washington 25, D. C. (April 1, 1963), price $4.00.

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SECTION II.—FOOD

Strontium-90 and Calcium in Infant and Adult Diets[1]

1959–1962

Joseph Rivera[2]

Since the rate of bone formation is high during the first year of life, it is particularly important to know the dietary intake of strontium-90 during this period so that reasonable estimates can be made of body burdens of strontium-90 in young children. The dietary estimates of strontium-90 intake are complicated since the foods eaten at this age are especially processed and may not have the same strontium-90 concentrations as the same type foods prepared for adult consumption.

Previous studies on this problem at the Health and Safety Laboratory suggested that a good indication of the strontium-90 and calcium content of infant diets could be made by analyzing only formula and evaporated milks prepared especially for infant use (*1*). With this in mind, formula and evaporated milks were added to the purchasing lists used in the tri-city diet surveys (*2*) at New York City, Chicago, and San Francisco. Results of the analyses of samples obtained from April 1962 to November 1962 are presented in table 1.

From these data, estimates of the Sr^{90}/Ca ratio in the total diet of 0-1-year-old infants were made. Since formula and evaporated milks provide about 89 percent of the strontium-90 intake and about 81 percent of the calcium intake during the first year of life (*1*), the Sr^{90}/Ca ratio in the infant total diet can be estimated by computing the Sr^{90}/Ca ratio of the milk component of the diet and multiplying this by 0.91. The Sr^{90}/Ca ratio of the milk component of the diet was calculated by summing the yearly strontium-90 contribution from formula and evaporated milks (assuming that 55 g Ca per year were taken in via formula milk consumption and 301 g Ca per year were taken via evaporated milk consumption) and dividing by the yearly calcium intake (356 g Ca/year) from these sources (*1*).

Estimates of the Sr^{90}/Ca ratio of the diet during the first year of life, along with previous data on infant diets (where diet components other than formula and evaporated milk were measured), are shown in table 2. Also shown are adult diet results obtained from the tri-city diet survey (*2*).

It is fairly apparent that the Sr^{90}/Ca ratios in infant diets have been essentially the same as those in adult diets despite the difference between the composition of the diets.

In a recent survey of consumption of whole fresh milk in the United States, it was found that only 30 percent of infants in the 0-1-year-old bracket consumed at least one quart of milk per day (*3*). The implication of this finding is that 70 percent of infants in this age range were drinking some formula and evaporated milks or were being

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[1] Originally published in *Fallout Quarterly Summary Report, HASL-135* (April 1, 1963).

[2] Mr. Rivera is a physicist on the staff of Environmental Studies Division of the Health and Safety Laboratory, U. S. Atomic Energy Commission.

TABLE 1.—RADIONUCLIDES IN CONSTITUENTS OF INFANT DIETS

Location	Month (1962)	Formula milk		Evaporated milk		Fresh liquid milk	
		pc Sr^{90}/g Ca	Sr^{89}/Sr^{90}	pc Sr^{90}/g Ca	Sr^{89}/Sr^{90}	pc Sr^{90}/g Ca	Sr^{89}/Sr^{90}
New York City	Aug.	17.0	2.1	8.1	[a]N D	16.2	6
	Nov.	12.7	0.8	18.7	1.2	13.6	2.6
Chicago	April	7.3	1.9	5.1	1.1	4.8	1.3
	July	15.4	2.5	20.5	2.1	11.5	3.3
	Oct.	11.8	1.7	18.4	2.3	8.5	5.8
San Francisco	May	6.5	0.5	2.6	6	5.3	12
	June	6.1	5.6	[b]—	[b]—	2.4	5
	Sept.	20.7	2.1	3.8	1.2	3.1	2.3

[a] Not determinable.
[b] Sample lost.

TABLE 2.—ESTIMATED PICOCURIES OF STRONTIUM-90 PER GRAM CALCIUM IN INFANT AND ADULT DIETS

Location and date	Total diet		Fresh Liquid milk
	Infant 0–1 yr.	Adult	
New York			
Aug. 59	14	18	11
Aug. 60	7	11	9
Aug. 61	6	9	5
Aug. 62	[a]9	14	16
Nov. 62	[a]17	17	14
Chicago			
Aug. 61	5	6	[b]4
April 62	[a]5	8	5
July 62	[a]18	13	12
Oct. 62	[a]16	14	9
San Francisco			
Aug. 61	3	3	[b]5
May 62	[a]3	5	5
June 62	[c]—	5	2
Sept. 62	[a]6	6	3

[a] Calculated from formula and evaporated milk strontium-90 concentration.
[b] Data from PHS Pasteurized Milk Network.
[c] No sample.

breast fed. Thus the diet estimates presented here, based on the consumption of these processed milks, are probably valid for at least half of the infants residing in the metropolitan areas of the three cities.

REFERENCES

(*1*) U. S. Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL–122*:185–7, Office of Technical Services, Department of Commerce, Washington 25, D. C. (April 1, 1962), price $3.00.

(*2*) Rivera, J.: Tri-City Diet Study, August–September 1962, *Radiological Health Data*, 4:289–90, Superintendent of Documents, Government Printing Office, Washington 25, D. C. (June 1963).

(*3*) Bureau of the Census, Department of Commerce and Division of Radiological Health, Public Health Service: National Food Consumption Survey—Fresh Whole Milk Consumption in the United States, July 1962, *Radiological Health Data*, 4:15–17 (January 1963).

SECTION III.—MILK

Milk Surveillance

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the U.S. population and contains most of the radionuclides identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

PASTEURIZED MILK NETWORK
April 1963

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a [illegible]-station raw milk monitoring network, which was established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a 46-station pasteurized milk sampling program in July 1960. The 46 stations were selected to provide general nationwide coverage of milk production and consumption areas.

As further needs developed, more milk sampling points were added, through July 1962, when the total number of stations reached was 62. Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. After collection, the composites are preserved with formaldehyde and are sent to the PHS Southwestern, Southeastern, and Northeastern Radiological Health laboratories for analyses. Approximately 3–6 days after sample collection, any results from the gamma analyses for iodine–131 which indicate concentrations of this radionuclide greather than 100 pc/liter are made available to State public health officials and the Federal Radiation Council for possible public health action. Complete analytical results are available 6 to 7 weeks after sample collection; publication in *Radiological Health Data* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method of compositing specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's sales in the community served. At most stations, the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961 and continuing at most stations through January 1963, sampling was done twice a week or daily for short periods at selected stations. Since then, sampling at most stations has been reduced to once a week.

All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention. Further atmospheric nuclear testing may require re-evaluation and adjustment of the sampling frequency and schedule of analyses for this program.

Analytical Errors in Radionuclide Measurements

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy,[1] while strontium-89 and strontium-90 concentrations are determined by radiochemical procedures. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation is relatively high. The variation is dependent upon the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. The minimum detectable concentration is defined as that concentration at which the statistical two-standard-deviation error is 100 percent of the measured concentration (*1*). Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Data Presentation

Table 1 presents summaries of all available analyses for April 1963, (March 31–April 27, 1963). When a radionuclide is reported by a laboratory as being below minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average. Although no data are presented on the stable potassium concentrations in milk, analyses have indicated that the usual range of concentrations is from 1.3 to 1.7 grams/liter. In April, for example, 5, 18, 10, 25, and 3 stations reported their respective monthly average potassium concentrations to be 1.3, 1.4, 1.5, 1.6, and 1.7 grams/liter. One station reported 1.1 grams/liter.

Figures 1 and 2 are isoconcentration maps showing the estimated radionuclide concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station.

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

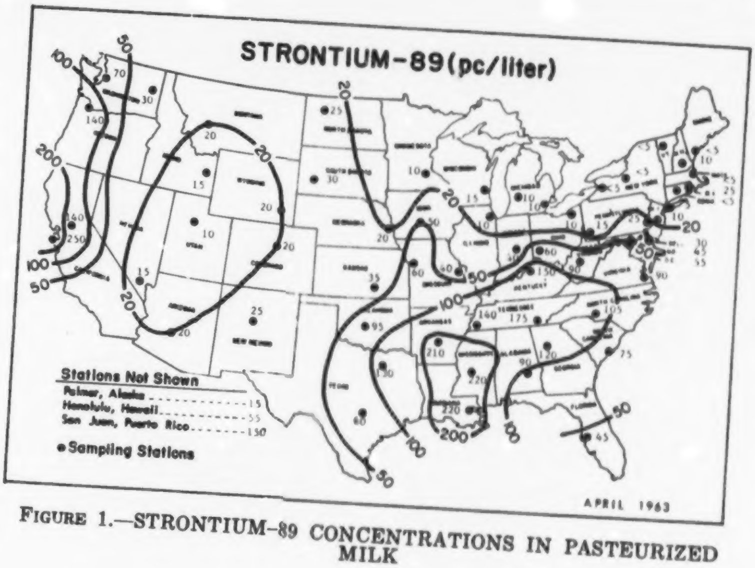
STRONTIUM-89(pc/liter)
Stations Not Shown
Palmer, Alaska 15
Honolulu, Hawaii 55
San Juan, Puerto Rico 150
● Sampling Stations
APRIL 1963

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK

TABLE 1.—RADIOACTIVITY IN PASTEURIZED MILK, APRIL 1963

[Average radioactivity concentrations in pc/liter]

Sampling locations	Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month
Ala: Montgomery	1.26	1.21	85	90	18	22	<10	<10	50	60	10	20
Alaska: Palmer	1.19	1.20	20	15	11	10	10	<10	65	50	10	<10
Ariz: Phoenix	1.20	1.18	20	20	4	5	<10	<10	20	15	<10	<10
Ark: Little Rock	1.23	1.20	125	210	34	50	20	<10	90	150	20	40
Calif: Sacramento	1.23	1.24	25	140	4	20	10	<10	30	80	10	<10
San Francisco	1.26	1.26	85	250	8	38	10	<10	35	120	10	<10
Colo: Denver	1.29	1.23	15	20	11	9	20	<10	65	55	<10	10
Conn: Hartford	1.11	1.07	<5	<5	12	12	<10	<10	65	60	<10	<10
Del: Wilmington	1.13	1.06	5	30	17	13	<10	<10	70	70	<10	<10
D.C: Washington	1.22	1.20	10	55	15	20	<10	<10	60	85	<10	10
Fla: Tampa	1.24	1.18	50	45	14	12	20	<10	185	185	<10	20
Ga: Atlanta	1.24	1.23	100	120	21	31	10	<10	85	120	20	20
Hawaii: Honolulu	1.14	1.19	55	55	8	11	20	<10	55	50	10	<10
Idaho: Idaho Falls	1.25	1.23	10	15	11	10	10	<10	75	80	<10	<10
Ill: Chicago	1.13	1.09	<5	10	16	14	<10	<10	70	80	<10	<10
Ind: Indianapolis	1.15	1.10	10	40	16	19	<10	<10	60	75	<10	<10
Iowa: Des Moines	1.23	1.22	15	50	14	18	10	<10	65	60	10	<10
Kans: Wichita	1.25	1.24	20	35	12	12	10	<10	50	55	10	<10
Ky: Louisville	1.22	1.19	35	150	20	30	<10	<10	55	75	<10	20
La: New Orleans	1.27	1.22	265	220	37	53	20	20	120	160	30	40
Maine: Portland	1.14	1.10	<5	<5	20	17	<10	<10	105	100	<10	<10
Md: Baltimore	1.23	1.14	5	45	14	15	<10	<10	65	80	<10	20
Mass: Boston	1.14	1.13	<5	<5	19	17	<10	<10	95	90	<10	<10
Mich: Detroit	1.16	1.10	<5	10	18	11	<10	<10	75	70	<10	<10
Grand Rapids	1.16	1.08	5	10	15	10	10	<10	75	70	<10	<10
Minn: Minneapolis	1.20	1.21	15	10	17	16	10	<10	110	95	10	<10
Miss: Jackson	1.33	1.26	230	220	32	43	20	<10	80	110	30	40
Mo: Kansas City	1.23	1.22	25	60	14	18	<10	<10	50	45	10	<10
St. Louis	1.24	1.20	20	40	11	14	10	<10	60	55	20	<10
Mont: Helena	1.18	1.18	20	20	13	15	10	<10	90	80	20	<10
Nebr: Omaha	1.25	1.16	20	20	14	16	10	<10	65	65	10	<10
Nev: Las Vegas	1.18	1.14	10	15	6	4	<10	<10	45	45	10	<10
N.H: Manchester	1.16	1.10	<5	10	18	16	10	<10	110	110	<10	<10
N.J: Trenton	1.14	1.10	<5	10	13	19	<10	<10	65	60	<10	<10
N. Mex: Albuquerque	1.23	1.19	15	25	4	8	<10	<10	30	20	10	<10
N.Y: Buffalo	1.11	1.06	5	<5	16	14	<10	<10	85	80	<10	<10
New York	1.12	1.12	<5	5	16	13	<10	<10	65	60	<10	<10
Syracuse	1.12	1.06	<5	<5	13	14	<10	<10	65	60	<10	<10
N.C: Charlotte	1.27	1.25	30	105	22	28	<10	<10	60	85	<10	20
N. Dak: Minot	1.21	1.12	15	25	23	25	<10	<10	85	70	20	<10
Ohio: Cincinnati	1.11	1.07	15	60	17	20	<10	<10	55	60	<10	<10
Cleveland	1.12	1.13	<5	10	14	14	<10	<10	60	65	<10	<10
Okla: Oklahoma City	1.23	1.18	60	95	20	22	20	<10	55	75	10	20
Ore: Portland	1.25	1.25	55	140	11	29	<10	<10	70	105	20	<10
Pa: Philadelphia	1.13	1.08	5	25	18	18	<10	<10	65	70	<10	<10
Pittsburgh	1.13	1.08	5	15	18	15	<10	<10	80	80	<10	<10
P.R: San Juan	1.20	1.18	135	150	12	20	20	<10	65	115	20	30
R.I: Providence	1.13	1.10	5	25	16	14	<10	<10	75	80	<10	<10
S.C: Charleston	1.26	1.23	105	75	23	31	20	<10	80	95	20	20
S. Dak: Rapid City	1.00	0.92	25	30	13	17	10	<10	80	65	<10	<10
Tenn: Chattanooga	1.29	1.22	75	175	23	34	<10	<10	65	110	10	20
Memphis	1.26	1.24	100	140	23	34	10	<10	50	65	20	20
Tex: Austin	1.22	1.18	50	60	8	11	10	<10	30	45	<10	<10
Dallas	1.25	1.16	110	130	20	24	20	10	60	75	20	20
Utah: Salt Lake City	1.26	1.25	15	10	12	12	10	<10	100	80	10	<10
Vt: Burlington	1.11	1.12	<5	<5	16	18	<10	<10	85	80	<10	<10
Va: Norfolk	1.25	1.16	30	90	17	22	<10	<10	65	90	<10	20
Wash: Seattle	1.24	1.25	30	70	10	18	10	<10	75	95	10	<10
Spokane	1.31	1.24	15	30	12	15	10	<10	85	80	10	<10
W. Va: Charleston	1.23	1.19	15	90	19	28	<10	<10	50	80	<10	20
Wis: Milwaukee	1.14	1.12	10	15	11	11	<10	<10	65	70	<10	<10
Wyo: Laramie	1.24	1.19	20	20	12	13	<10	<10	95	110	20	10
Network average	1.20	1.16	37	59	15.6	19.1	<10	<10	70	79	<10	10

Selected Monthly Strontium-90 Profiles

Continuing the practice followed in previous issues of *RHD*, average monthly strontium-90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented (see figure 3). Each individual graph shows the strontium-90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions. This method of selection permits the graphical presentation of data from every city in the network at least twice a year.

REFERENCE

(*1*) Division of Radiological Health, Public Health Service: Pasteurized Milk Network, February 1963, *Radiological Health Data*, 4:291-6, Superintendent of Documents, Government Printing Office, Washington 25, D. C. (June 1963).

77

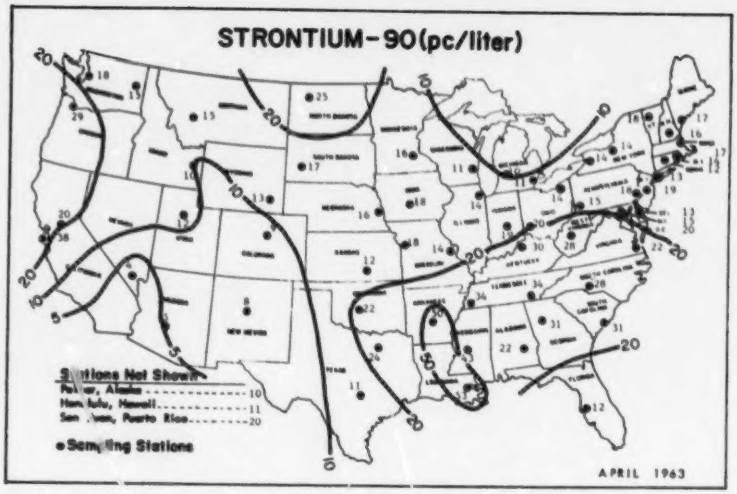
STRONTIUM-90(pc/liter)
Stations Not Shown
Palmer, Alaska ---------- 10
Honolulu, Hawaii ---------- 11
San Juan, Puerto Rico ---------- 20
Sampling Stations
APRIL 1963

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

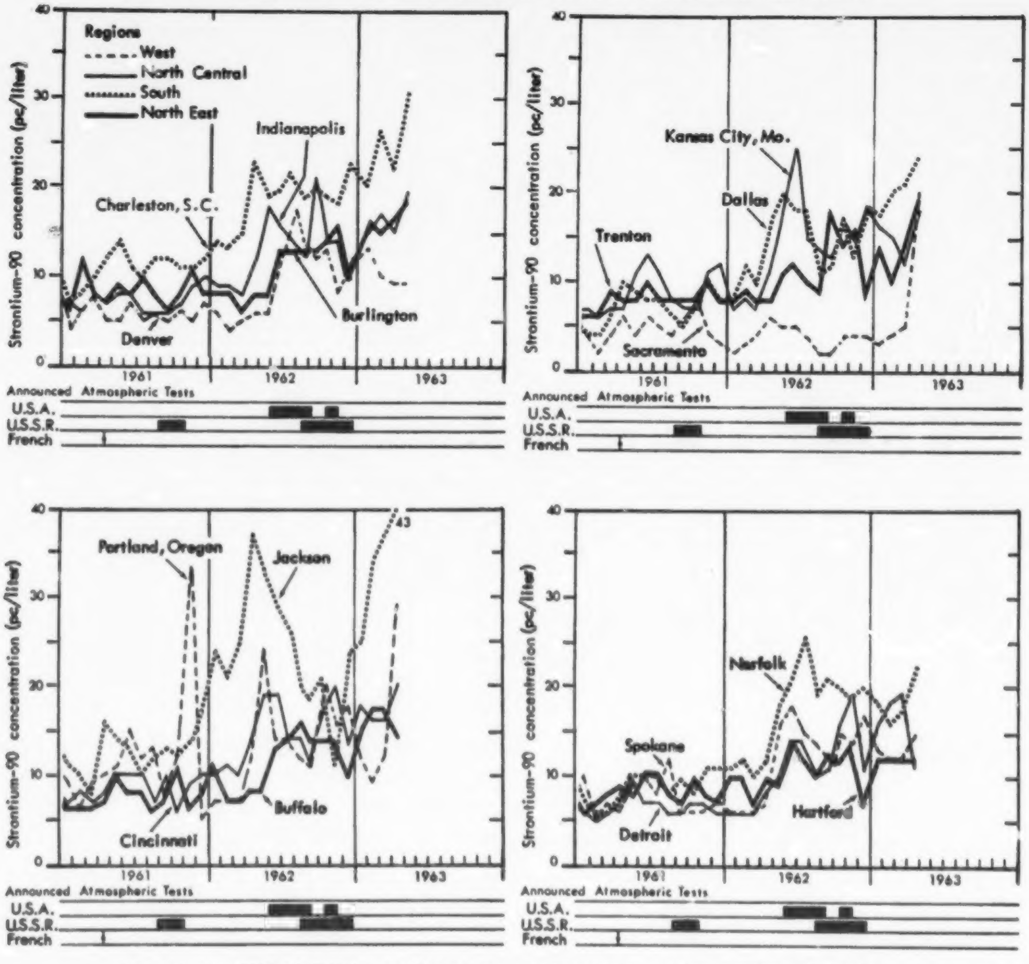

FIGURE 3.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

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CALIFORNIA MILK NETWORK
October 1962–March 1963

State of California
Department of Public Health

Surveillance of the concentrations of specific radionuclides in milk is one phase of California's Department of Public Health program of radiation control. This milk monitoring function has been conducted since 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation.

The surveillance program involves the weekly sampling of milk from 10 major milksheds (see figure 4). Radiostrontium is separated chemically and counted in a low background counter. The usual counting time is 60 minutes. Iodine-131, cesium-137, and barium-lanthanum-140 are determined on the fluid milk by gamma scintillation spectroscopy using a sodium iodide crystal. A normal counting time of 100 minutes is used.

The monthly averages of the data are presented in table 2. When the result from an individual analysis was reported as not significant, a value of zero was used in calculating the average.

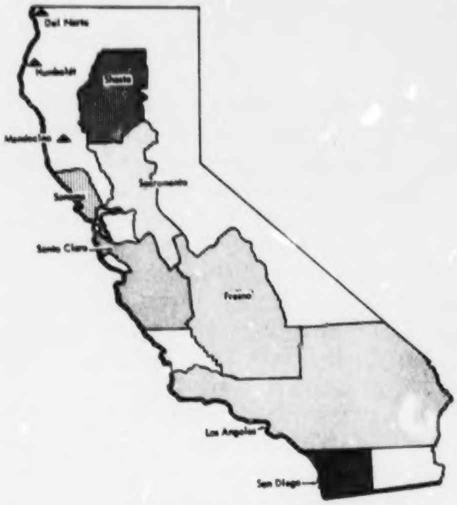

FIGURE 4.—CALIFORNIA MILKSHEDS

TABLE 2.—RADIONUCLIDES IN CALIFORNIA MILK, OCTOBER 1962-MARCH 1963

[Radioactivity concentrations in pc/liter]

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma
Calcium (g/liter)										
January 1963	1.36	1.25	1.20	1.13	1.17	1.19	1.17	1.16	1.17	1.22
February 1963	1.35	1.19	1.22	1.14	1.17	1.16	1.15	1.13	1.17	1.21
March 1963	1.33	1.18	1.19	1.11	1.19	1.18	1.14	1.13	1.14	1.20
Strontium-89										
January 1963	581	4	164	5	15	10	66	6	13	31
February 1963	619	5	241	5	20	10	53	6	15	81
March 1963	821	16	258	8	120	34	13	21	39	159
Strontium-90										
January 1963	49	2	12	3	4	3	2	3	4	6
February 1963	56	2	16	2	4	4	2	2	6	7
March 1963	82	6	27	3	11	5	3	5	7	14
Iodine-131										
October 1962	57	[a]0	9	8	8	6	11	0	4	0
November 1962	47	0	78	0	0	6	8	0	0	26
December 1962	86	0	16	0	0	10	8	0	5	23
January 1963	13	0	9	0	0	0	0	0	0	0
February 1963	8	0	2	0	0	0	0	0	0	0
March 1963	0	0	0	0	0	0	0	0	0	0
Cesium-137										
October 1962	[b]215	[c]—	87	[b]23	[b]46	21	20	—	—	[b]22
November 1962	158	18	56	18	30	28	13	14	26	23
December 1962	153	9	54	11	26	23	10	9	85	32
January 1963	105	2	29	10	19	10	2	7	17	21
February 1963	169	15	73	18	26	20	8	16	29	39
March 1963	247	21	84	20	53	28	14	16	39	61
Barium-lanthanum-140										
October 1962	[b]81	—	29	—	[b]0	[b]0	20	—	—	—
November 1962	281	—	42	[b]0	—	—	13	—	—	[b]0
December 1962	87	0	19	0	0	0	10	0	0	4
January 1963	22	0	0	0	0	0	0	0	0	0
February 1963	24	0	6	[b]0	0	0	[b]0	—	[b]0	0
March 1963	—	—	—	—	—	—	—	—	—	—

[a] .. zero indicates no significant activity.
[b] Single sample.
[c] A dash indicates no sample.

NEW YORK MILK NETWORK
January–March 1963

Division of Environmental Health Services
State of New York Department of Health

Milk samples, collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 5)—are analyzed for radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium–89, strontium–90, iodine–131 and cesium–107 at all stations except Massena, where samples are composited bi-weekly, and at New York City, where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed for iodine–131 daily. In the event that any city reports iodine–131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

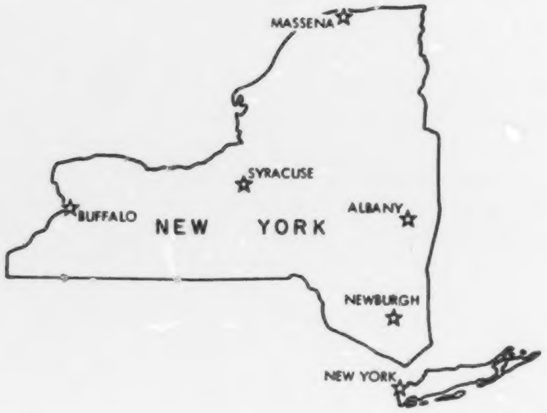

FIGURE 5.—NEW YORK MILK SAMPLING LOCATIONS

The matrix method (1) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

TABLE 3.—RADIONUCLIDES IN NEW YORK MILK, JANUARY-MARCH 1963

[Concentrations in pc/liter]

Sampling location	Strontium–89			Strontium–90			Iodine–131			Cesium–137		
	Jan.	Feb.	Mar.	Jan.	Feb.	Mar.	Jan.	Feb.	Mar.	Jan.	Feb.	Mar.
Albany	4	4	<3	6	6	7	<20	<20	<20	54	63	51
Buffalo	5	5	4	8	9	9	<20	<20	<20	62	87	60
Massena	[a]—	9	6	—	10	9	<20	<20	<20	127	117	129
Newburgh	5	7	16	8	6	7	<20	<20	<20	55	61	48
New York City	7	4	4	9	9	8	<20	<20	28	—	—	46
Syracuse	5	5	4	6	5	6	<20	<20	<20	55	28	31

[a] Dash indicates no sample or analysis made.

The analytical procedure for strontium–89 and strontium–90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm^2 window. The strontium–90 portion is differentially estimated by a second count 40 hours later to determine the rate of growth of its daughter product, yttrium–90.

The monthly average radionuclide concentrations in milk are shown in table 3.

REFERENCE

(1) Kahn, B., et al.: *Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Publication No. 999–R–2.* Single free copies may be obtained from Public Inquiries Branch, PHS, U. S. Department of Health, Education, and Welfare, Washington 25, D. C.

CANADIAN MILK NETWORK[1]
March 1963

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

In January 1963, the Canadian Department of National Health and Welfare substituted the radioanalysis of fresh liquid milk for the analysis of powdered milk. The Department had analyzed milk powders from November 1955 through December 1962, but liquid whole milk had been monitored since April 1962 for iodine–131 only.

With this change, it has been possible to choose milk sampling locations (see figure 6) in the same areas as the air and precipitation stations. This permits the observation of a number of environmental variables which may affect the radionuclide levels in milk. In addition, it is now possible to report radionuclide concentrations in terms of the activity per liter of milk as well as per gram of calcium in milk.

A detailed discussion of the sampling and radiochemical procedures employed for milk analyses

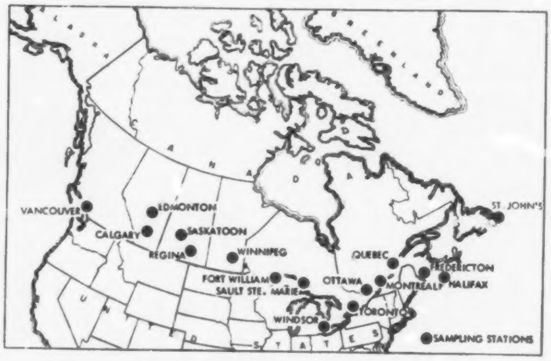

FIGURE 6.—CANADIAN MILK SAMPLING STATIONS

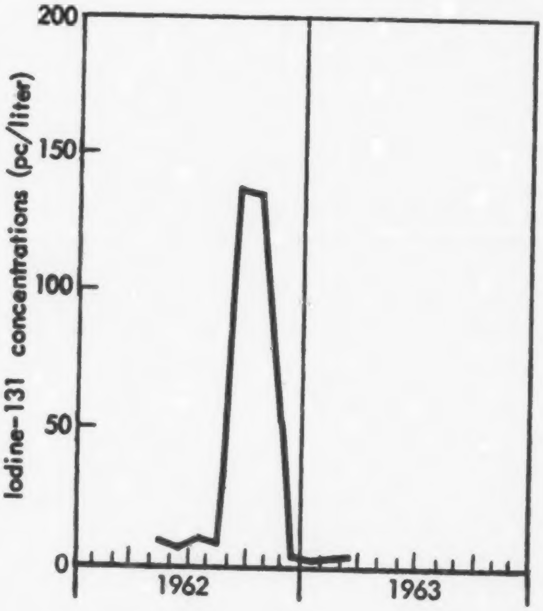

FIGURE 7.—IODINE-131 CONCENTRATIONS IN WHOLE MILK

TABLE 4.—RADIONUCLIDES IN CANADIAN WHOLE MILK, MARCH 1963

Station	Calcium (g/liter)	Strontium-89 (pc/liter)	Strontium-90 (pc/liter)	Iodine-131 (pc/liter)	Cesium-137 (pc/liter)
Calgary	1.09	16	23.6	9	52
Edmonton	1.14	9	19.6	[b]—	42
Fort William	1.13	13	26.6	—	58
Fredericton	1.27	4	28.2	—	116
Halifax	1.27	11	19.9	3	84
Montreal	1.18	12	16.4	—	40
Ottawa	1.15	12	12.3	4	31
Quebec	1.15	4	22.5	2	91
Regina	1.01	8	17.5	—	19
Saint John's	1.14	14	19.5	—	17
Saskatoon	1.17	25	14.2	15	36
Sault Ste. Marie	1.10	183	18.1	3	54
Toronto	1.13	11	10.8	—	74
Vancouver	1.24	8	20.4	1	67
Windsor	1.19	11	11.2	0	28
Winnipeg	1.18	13	17.8	0	32
Average	1.16	22	18.7	4	53

[a] Each of the iodine-131 values is an average of nine samples.
[b] A dash indicates no sample.

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[1] Data from *Radiation Protection Programs*, Radiation Protection Division, Canadian Department of National Health and Welfare.

may be found in the Department's publications (*1, 2*). Table 4 presents the results of the measurements of strontium-89, strontium-90, cesium-137, and iodine-131 (see figure 7) in Canadian liquid whole milk for March.

It should be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the concentration levels in a particular medium with the so-called Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*3*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period, such as one year, represent a better basis for comparison than do individual levels at any specific time.

REFERENECS

(*1*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurements of Radioactive Strontium in Canadian Milk Powder Samples, CNHW-RP-1*, (July 1958).

(*2*) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, RPD-5*, Radiation Protection Division, Department of National Health and Welfare (June 1, 1960).

(*3*) Recommendations of the International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

Twelve-Month Sum of Daily Radionuclide Content of One Liter of Pasteurized Milk

Iodine-131: June 1962-May 1963
Strontium-89 and Strontium-90: May 1962-April 1963

Division of Radiological Health,
Public Health Service

The guidance of the Federal Radiation Council (FRC) is given in terms of transient rates of intake of radioactive materials in picocuries per day. The action ranges proposed in FRC Report No. 2 are based on radiation doses considered acceptable for lifetime exposure from normal peacetime atomic industry operations (*1*). The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures and emphasizes that the annual acceptable exposure dose is not a "danger point" which, if exceeded, requires protective measures (*1, 2, 3*).

To facilitate comparison of the concentrations of certain radionuclides in milk with the Radiation Protection Guides, tables 1 and 2 furnish estimates of the contribution of milk to the total dietary intake of iodine-131, strontium-89, and strontium-90. The tables are developed from the PHS Pasteurized Milk Network monthly averages of the radionuclides. The index values are estimated sums of the daily amounts of a radionculide in one liter of milk for a 12-month period.

The tables show 12-month index values for each of the Network's 62 sampling locations. Due to the longer time required for strontium-89 and strontium-90 analysis, these 12-month index values are for the year beginning one month earlier than the iodine-131 values. Columns (B) and (C) in each table are used to compute the net change as the yearly index values are advanced by one month. Column (D) shows this new 12-month index value. In addition, the second column in table 1 gives the average iodine-131 concentrations for May 1963.

The data in tables 1 and 2 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly averages for all weeks ending within a given month are averaged and an average for the month is obtained, and (c) the monthly radionuclide index value is determined by multiplying the average for the month by the number of days in the month. The number of days in the month will be either 28 or 35, corresponding to the complete calendar weeks ending in a given month. Procedures exemplified by (a) and (b) above tend to minimize the effect of any one day's sample results on the average for the month, particularly for a short-lived radionuclide such as iodine-131. The yearly index values are obtained by the following procedure. Column (A) gives twelve month index values for the period indicated. Columns

TABLE 1.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

Sampling locations		May 1963 iodine-131 averages (pc/liter)	Iodine-131 index values[a] (pc day/liter)			
			May 1962–Apr. 1963 (A)	Apr. 29–May 26, 1962 (B)	Apr. 28–May 25, 1963 (C)	June 1962–May 1963 (D)
Ala:	Montgomery	<10	6, 590	560	140	6, 170
Alaska:	Palmer	<10	38, 050	140	140	38, 050
Ariz:	Phoenix	<10	4, 100	140	140	4, 100
Ark:	Little Rock	<10	14, 480	560	140	14, 420
Calif:	Sacramento	<10	5, 050	560	140	4, 630
	San Francisco	<10	4, 630	140	140	4, 630
Colo:	Denver	<10	6, 240	280	140	6, 100
Conn:	Hartford	<10	7, 670	140	140	7, 670
Del:	Wilmington	<10	11, 870	140	140	11, 870
D.C:	Washington	<10	8, 440	140	140	8, 440
Fla:	Tampa	<10	6, 660	140	140	6, 660
Ga:	Atlanta	<10	9, 040	280	140	8, 900
Hawaii:	Honolulu	<10	4, 730	280	140	4, 590
Idaho:	Idaho Falls	<10	9, 070	140	140	9, 070
Ill:	Chicago	<10	13, 690	1, 120	140	12, 710
Ind:	Indianapolis	<10	12, 010	280	140	11, 870
Iowa:	Des Moines	<10	21, 670	2, 520	140	19, 290
Kans:	Wichita	<10	21, 740	6, 160	140	15, 720
Ky:	Louisville	<10	10, 540	560	140	10, 120
La:	New Orleans	<10	10, 190	140	140	10, 190
Maine:	Portland	<10	8, 160	140	140	8, 160
Md:	Baltimore	<10	8, 690	560	140	8, 270
Mass:	Boston	<10	7, 950	140	140	7, 950
Mich:	Detroit	<10	12, 820	280	140	12, 680
	Grand Rapids	<10	9, 730	140	140	9, 730
Minn:	Minneapolis	<10	15, 650	3, 360	140	12, 430
Miss:	Jackson	<10	9, 700	140	140	9, 700
Mo:	Kansas City	<10	30, 070	5, 600	140	24, 610
	St. Louis	<10	12, 360	840	140	11, 660
Mont:	Helena	<10	14, 110	280	140	13, 970
Nebr:	Omaha	<10	19, 220	840	140	18, 520
Nev:	Las Vegas[b]	<10	4, 730	[c]—	140	4, 870
N.H:	Manchester	<10	7, 710	140	140	7, 710
N.J:	Trenton	<10	7, 990	140	140	7, 990
N. Mex:	Albuquerque	<10	6, 380	560	140	5, 960
N.Y:	Buffalo	<10	8, 720	140	140	8, 720
	New York	<10	11, 660	560	140	11, 240
	Syracuse	<10	10, 150	560	140	9, 730
N.C:	Charlotte	<10	3, 370	140	140	3, 370
N. Dak:	Minot	<10	14, 910	560	140	14, 490
Ohio:	Cincinnati	<10	14, 600	560	140	14, 180
	Cleveland	<10	11, 100	140	140	11, 100
Okla:	Oklahoma City	<10	18, 380	560	140	17, 960
Ore:	Portland	<10	9, 770	140	140	9, 770
Pa:	Philadelphia	<10	10, 820	140	140	10, 820
	Pittsburgh	<10	14, 810	140	140	14, 810
P.R:	San Juan[d]	<10	6, 130	560	140	5, 710
R.I:	Providence	<10	8, 580	560	140	8, 160
S.C:	Charleston	<10	7, 180	140	140	7, 180
S. Dak:	Rapid City	<10	14, 150	140	140	14, 150
Tenn:	Chattanooga	<10	7, 850	560	140	7, 430
	Memphis	<10	10, 050	140	140	10, 050
Tex:	Austin	<10	11, 040	140	140	11, 040
	Dallas	<10	18, 980	560	140	18, 560
Utah:	Salt Lake City	<10	31, 920	140	140	31, 920
Vt:	Burlington	<10	8, 380	140	140	8, 380
Va:	Norfolk	<10	6, 410	280	140	6, 270
Wash:	Seattle	<10	9, 770	140	140	9, 770
	Spokane	<10	21, 390	140	140	21, 390
W. Va:	Charleston	<10	6, 970	560	140	6, 550
Wis:	Milwaukee	<10	14, 460	280	140	14, 320
Wyo:	Laramie	<10	19, 540	560	140	19, 120

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[a] The data in this table are index values, not to be interpreted as consumption or total intake values. The average per-person annual iodine-131 intake from milk may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month I^{131} index × milk consumption factor = 12-month I^{131} intake
(pc day/liter) (liter/day/person) (pc/person)

[b] Station included in milk network in July 1962. The sums in columns A and D are therefore for 10 and 11 months respectively.

[c] A dash indicates no analysis.

[d] No sample was received in November 1962. The sums in columns A and D are therefore for 11 months.

TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-89 AND STRONTIUM-90 IN ONE LITER OF MILK

[pc day/liter]

Sampling locations	Strontium-89 index values[a]				Strontium-90 index values[a]			
	Apr. 1962–Mar. 1963 (A)	Apr. 1–28, 1962 (B)	Mar. 31, 1963–Apr. 27, 1963 (C)	May 1962–Apr. 1963 (D)	Apr. 1962–Mar. 1963 (A)	Apr. 1–28, 1962 (B)	Mar. 31, 1963–Apr. 27, 1963 (C)	May 1962–Apr. 1963 (D)
Ala: Montgomery	23,905	4,760	2,520	21,665	5,866	644	616	5,838
Alaska: Palmer	19,985	420	420	19,985	4,095	168	280	4,207
Ariz: Phoenix	6,425	560	560	6,425	1,211	84	140	1,267
Ark: Little Rock	49,665	10,640	5,880	44,905	11,767	1,120	1,400	12,047
Calif: Sacramento	7,720	1,260	3,920	10,380	1,456	168	560	1,848
San Francisco	15,645	2,240	7,000	20,405	2,212	280	1,064	2,996
Colo: Denver	10,920	280	560	11,200	4,039	168	252	4,123
Conn: Hartford	8,140	140	70	8,070	4,158	280	336	4,214
Del: Wilmington	12,935	1,540	840	12,235	5,453	392	364	5,425
D.C: Washington	13,020	1,120	1,540	13,440	5,817	336	560	6,041
Fla: Tampa	11,690	840	1,260	12,110	4,081	252	236	4,165
Ga: Atlanta	28,980	4,900	3,360	27,440	7,119	700	868	7,287
Hawaii: Honolulu	10,885	1,120	1,540	11,305	2,114	168	308	2,254
Idaho: Idaho Falls	9,275	140	420	9,555	3,871	112	280	4,039
Ill: Chicago	10,800	70	280	11,010	4,893	196	392	5,089
Ind: Indianapolis	13,790	840	1,120	14,070	5,418	336	532	5,614
Iowa: Des Moines	24,710	840	1,400	25,270	5,250	224	504	5,530
Kans: Wichita	18,270	980	980	18,270	4,543	224	336	4,655
Ky: Louisville	28,840	3,080	4,200	29,960	7,868	504	840	8,204
La: New Orleans	57,260	7,980	6,160	55,440	11,746	1,120	1,484	12,110
Maine: Portland	10,800	70	70	10,800	5,852	364	476	5,964
Md: Baltimore	12,005	840	1,260	12,425	5,824	308	420	5,936
Mass: Boston	11,430	70	70	11,430	6,657	336	476	6,797
Mich: Detroit	9,855	140	280	9,995	5,033	224	308	5,117
Grand Rapids	8,560	70	280	8,770	4,249	224	280	4,305
Minn: Minneapolis	20,860	140	280	21,000	6,811	140	448	7,119
Miss: Jackson	55,825	9,520	6,160	52,465	9,576	1,036	1,204	9,744
Mo: Kansas City	31,430	1,680	1,680	31,430	5,775	308	504	5,971
St. Louis	20,090	1,120	1,120	20,090	5,173	280	392	5,285
Mont: Helena	17,395	560	560	17,395	4,984	112	420	5,292
Nebr: Omaha	21,560	840	560	21,280	5,372	168	448	5,652
Nev: Las Vegas[b]	5,775	[c]—	420	6,195	1,512	—	112	1,624
N.H: Manchester	10,415	70	280	10,625	5,789	308	448	5,929
N.J: Trenton	9,995	560	280	9,715	4,396	224	532	4,704
N. Mex: Albuquerque	6,795	560	700	6,935	1,666	84	224	1,806
N.Y: Buffalo	8,980	70	70	8,980	4,858	224	392	5,026
New York	10,555	70	140	10,625	5,551	252	364	5,663
Syracuse	9,540	70	70	9,540	4,564	224	392	4,732
N.C: Charlotte	20,860	3,500	2,940	20,300	7,791	476	784	8,099
N. Dak: Minot	17,650	140	700	18,210	8,106	196	700	8,610
Ohio: Cincinnati	17,325	1,680	1,680	17,325	5,831	392	560	5,999
Cleveland	10,730	70	280	10,940	4,781	252	392	4,921
Okla: Oklahoma City	27,160	2,660	2,660	27,160	7,007	448	616	7,175
Ore: Portland	32,270	2,240	3,920	33,950	5,257	336	812	5,733
Pa: Philadelphia	10,415	560	700	10,555	5,250	308	504	5,446
Pittsburgh	12,340	280	420	12,480	6,223	308	420	6,335
P.R: San Juan[d]	26,355	3,220	4,200	27,335	3,766	336	560	3,990
R.I: Providence	9,190	140	700	9,750	5,131	308	392	5,215
S.C: Charleston	26,845	4,060	2,100	22,885	7,620	644	868	7,847
S. Dak: Rapid City	21,315	280	840	21,875	6,08[illegible]	196	476	6,363
Tenn: Chattanooga	39,305	9,520	4,900	34,685	8,582	812	952	8,722
Memphis	36,645	6,720	3,920	33,845	8,351	784	952	8,519
Tex: Austin	12,285	1,260	1,680	12,705	2,814	224	308	2,898
Dallas	32,305	4,480	3,640	31,465	6,202	476	672	6,398
Utah: Salt Lake City	12,005	140	280	12,145	3,941	112	336	4,165
Vt: Burlington	11,045	70	70	11,045	4,844	224	504	5,124
Va: Norfolk	17,920	2,100	2,520	18,340	6,909	336	616	7,189
Wash: Seattle	23,065	1,400	1,960	23,625	5,740	280	504	5,964
Spokane	14,280	560	840	14,560	5,033	196	420	5,257
W. Va: Charleston	21,595	980	2,520	23,135	7,448	336	784	7,896
Wis: Milwaukee	8,665	70	420	9,015	3,549	168	308	3,689
Wyo: Laramie	20,440	280	560	20,720	4,263	112	364	4,515

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. The average per-person annual strontium-89 and strontium-90 intake from milk may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month Sr^{89} or Sr^{90} index (pc day/liter) × milk consumption factor (liter/day/person) = 12-month Sr^{89} or Sr^{90} intake (pc/person)

[b] Station included in network in July 1962. Sums in columns A and D are therefore for 9 and 10 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received for November 1962. The sums in columns A and D are therefore for 11 months.

(B) and (C) show the monthly index values for the periods indicated. The values in column (D) are obtained by adding the values in column (C) to those in column (A) and subtracting those in (B).

For a number of reasons, it is desirable to use a standard quantity of milk in the development of index values for the different radionuclides. When one is concerned with radio-strontium, 1 liter is a suitable quantity, as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the daily intake guidance for radio-strontium. When one is concerned with iodine-131, the critical age group is the young infant. Available information suggests that the average milk consumption of infants in the 6–18-month group is not more than 1 liter per day. Thus, the index value based on 1 liter of milk, though not directly an average intake value, is probably the most useful index for estimating total intake.

REFERENCES

(*1*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U. S. Government Printing Office (September 1961), price 20 cents.

(*2*) Chadwick, Donald R., and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data*, *3*:159–65, Superintendent of Documents, Government Printing Office, Washington 25, D. C. (May 1962).

(*3*) Public Health Service: Special Report, *Radiological Health Data*, *3*:ii–iii, Superintendent of Documents, Government Printing Office, Washington 25, D. C. (September 1962).

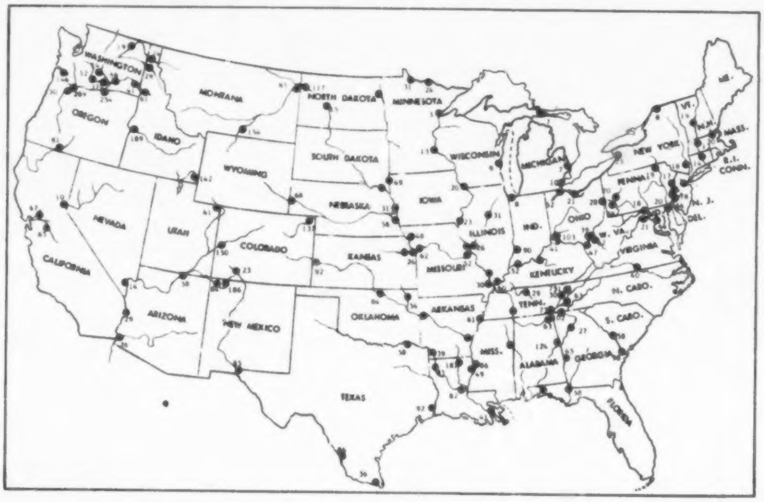
SECTION IV.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
February 1963

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service National Water Quality Network since its initiation in 1957. Beginning with the establishment of 50 sampling points, this network has expanded to 126 stations as of June 1, 1963, (figure 1), operated jointly with State, Federal and local agencies and industry. Surface waters of all major river basins of the United States are sampled and analyzed physically, chemically, biologically and radiologically. These data can then be used to evaluate sources of radioactivity which may effect all legitimate uses of surface water. Further, the Network provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the Network are published in an annual compilation (*1–6*).


WASHINGTON
OREGON
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MONTANA
NORTH DAKOTA
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SOUTH DAKOTA
WYOMING
WISCONSIN
MICHIGAN
NEW YORK
ME.
VT.
N.H.
MASS.
R.I.
CONN.
PENNA.
N. J.
DEL.
NEBRASKA
IOWA
ILLINOIS
IND.
OHIO
W. VA.
VIRGINIA
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
KENTUCKY
CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TENN.
N. CARO.
S. CARO.
MISS.
ALABAMA
GEORGIA
TEXAS
FLORIDA

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, FEBRUARY 1963

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TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Average concentration in pc/liter]

Station	February 1963					
	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa	4	16	20	0	0	0
Animas River: Cedar Hill, N. Mex	142	44	186	22	4	26
Apalachicola River: Chattahoochee, Fla	37	21	58	1	0	1
Arkansas River						
Coolidge, Kans	28	64	92	4	24	28
Ponca City, Okla	42	42	84	3	1	4
Bear River: Preston, Idaho	50	92	142	1	2	3
Bighorn River: Hardin, Mont	90	64	154	7	6	13
Big Sioux River: Sioux Falls, S. Dak	9	40	49	0	2	2
Chattahoochee River						
Atlanta, Ga	19	8	27	1	0	1
Columbus, Ga	30	15	45	0	0	0
Lanett, Ala	96	28	124	2	<1	2
Chena Slough: Fairbanks, Alaska	—	—	—	—	—	—
Clear Water River: Lewiston, Idaho	163	26	189	10	0	10
Clinch River						
Clinton, Tenn	14	16	30	1	0	1
Kingston, Tenn	191	560	751	2	<1	2
Colorado River						
Loma, Colo	90	60	150	7	6	13
Page, Ariz	5	53	58	1	12	13
Boulder City, Nev	1	13	14	0	6	6
Parker Dam, Calif-Ariz	0	29	29	0	6	6
Yuma, Ariz	1	25	26	0	4	4
Columbia River						
Northport, Wash	7	12	19	<1	1	1
Wenatchee, Wash	3	11	14	0	0	0
Pasco, Wash	32	342	374	0	0	0
McNary Dam, Ore	44	210	254	<1	<1	1
Bonneville, Ore	73	196	269	0	0	0
Clatskanie, Ore	54	90	144	—	—	—
Cumberland River: Clarksville, Tenn	13	16	29	1	0	1
Connecticut River						
Wilder, Vt	6	13	19	0	1	1
Northfield, Mass	3	10	13	1	0	1
Enfield Dam, Conn	0	14	14	0	0	0
Cuyahoga River: Cleveland, Ohio	4	17	21	0	1	1
Deleware River						
Martins Creek, Pa	6	11	17	0	0	0
Trenton, N.J	—	—	—	—	—	—
Philadelphia, Pa	46	32	78	1	1	2
Great Lakes						
Duluth, Minn	0	3	3	0	0	0
Sault Ste. Marie, Mich	1	6	7	0	0	0
Milwaukee, Wis	0	9	9	0	1	1
Gary, Ind	1	7	8	0	0	0
Port Huron, Mich	0	7	7	0	0	0
Detroit, Mich	2	8	10	0	0	0
Buffalo, N.Y	10	15	25	0	0	0
Green River: Dutch John, Utah	7	34	41	0	6	6
Hudson River: Poughkeepsie, N.Y	5	13	18	0	0	0
Illinois River						
Peoria, Ill	7	24	31	1	5	6
Grafton, Ill	—	—	—	—	—	—
Kanawha River: Winfield Dam, W. Va	12	40	52	2	20	22
Klamath River: Keno, Ore	46	35	81	0	0	0
Little Miami River: Cincinnati, Ohio	33	70	103	0	0	0
Maumee River: Toledo, Ohio	12	40	52	<1	2	2
Merrimack River: Lowell, Mass	8	22	30	<1	<1	1
Mississippi River						
St. Paul, Minn	0	13	13	0	0	0
Dubuque, Iowa	4	16	20	1	1	2
Burlington, Iowa	3	20	23	0	0	0
E. St. Louis, Ill	5	21	26	0	1	1
Cape Giraudeau, Mo	7	23	30	1	1	2
W. Memphis, Ark	39	22	61	1	0	1
Delta, La	28	21	49	2	1	3
New Orleans, La	19	22	41	0	0	0
Vicksburg, Miss	61	25	86	3	1	4
Missouri River						
Williston, N. Dak	53	64	117	0	3	3
Bismarch, N. Dak	0	15	15	0	2	2
Yankton, S. Dak	—	—	—	—	—	—
Omaha, Nebr	5	26	31	0	4	4
St. Joseph, Mo	21	27	48	1	4	5
Kansas City, Kans	4	20	24	1	6	7
St. Louis, Mo	15	37	52	3	3	6
Missouri City, Mo	24	38	62	3	7	10
Monongahela River: Pittsburgh, Pa	13	25	38	0	0	0
North Platte River: Henry, Nebr	15	53	68	<1	30	30
Ohio River						
E. Liverpool, Ohio	14	14	28	1	1	2
Addison, Ohio	15	24	39	<1	<1	1
Huntington, W. Va	29	18	47	2	1	3
Cincinnati, Ohio	24	17	41	2	0	2
Louisville, Ky	—	—	—	—	—	—
Evansville, Ind	36	16	52	1	0	1
Cairo, Ill	45	15	60	12	1	13
Ouachita River: Bastrop, La	100	87	187	3	4	7
Pend Oreille River: Albeni Falls Dam, Idaho	10	14	24	0	<1	<1
Platte River: Plattsmouth, Nebr	20	36	56	1	6	7
Potomac River						
Williamsport, Md	7	11	18	0	0	0
Great Falls, Md	11	33	44	0	0	0
Rainy River						
Baudette, Minn	10	21	31	1	1	2
International Fls, Minn	2	22	24	0	0	0
Red River, South						
Denison, Tex	13	45	58	0	12	12
Index, Ark	9	30	39	0	0	0
Alexandria, La	44	38	82	1	2	3
Bossier City, La	24	61	85	0	<1	<1
Rio Grande River						
Alamosa, Colo	4	19	23	0	1	1
El Paso, Tex	22	63	85	2	0	2
Laredo, Tex	36	50	86	0	1	1
Brownsville, Tex	14	22	36	0	4	4
Roanoke River: John H. Kerr Resr. & Dam, Va	27	13	40	1	0	1
Sabine River: Ruliff, Tex	49	43	92	0	0	0
Sacramento River: Greens Landing Courtland, Calif	47	20	67	1	1	2
San Joaquin River: Vernalis, Calif	32	33	65	2	1	3
San Juan River: Shiprock, N. Mex	38	46	84	2	12	14
St. Lawrence River: Massena, N.Y	0	8	8	0	0	0
Schuylkill River: Philadelphia, Pa	25	31	56	1	6	7
Savannah River						
North Augusta, Ga	32	26	58	0	0	0
Port Wentworth, Ga	42	56	98	1	0	1
Shenandoah River: Berryville, Va	6	15	21	0	0	0
Ship Creek: Anchorage, Alaska	9	13	22	1	0	1
Snake River						
Ice Harbor Dam, Wash	15	26	41	1	2	3
Wawawai, Wash	42	24	66	1	1	2
Payette, Idaho	28	33	61	1	3	4
South Platte River: Julesburg, Colo	54	83	137	4	33	37
Spokane River: Post Falls, Idaho	12	17	29	0	0	0
Susquehanna River						
Sayre, Pa	7	12	19	0	0	0
Conowingo, Md	6	14	20	0	1	1
Tennessee River						
Chattanooga, Tenn	46	56	102	1	0	1
Bridgeport, Ala	8	55	63	0	0	0
Pickwick Landing, Tenn	29	44	73	0	0	0
Lenoir City, Tenn	32	31	63	1	1	2
Tombigbee River: Columbus, Miss	—	—	—	—	—	—

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TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS—Continued

[Average concentrations in pc/liter)

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Truckee River: Farad, Calif.	4	6	10	0	0	0
Verdigris River: Nowata, Okla.	9	45	54	1	1	2
Wabash River: New Harmony, Ind.	23	67	90	<1	1	1
Willamette River: Portland, Ore.	15	15	30	0	0	0
Yakima River: Richland, Wash.	31	21	52	1	1	2
Yellowstone River: Sidney, Mont.	43	42	85	1	4	5

[1] These data are preliminary: reanalysis of some samples may be made and additional analyses, not completed at the time of the report, may become available. For final data one should consult the Network's *Annual Compilation of Data* (6).

[2] Dashes indicate data are not available.

One-liter grab samples are collected weekly by personnel of the participating agencies and shipped to the Public Health Service laboratory in Cincinnati for analysis. Determinations of gross alpha and gross beta radioactivity in the suspended and dissolved solids and strontium-90 activity in the total solids are carried out on frequency schedules based on need.

Gross beta activity in each weekly sample was determined until essentially background levels were reached in January 1960. Then, gross beta determinations were made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established Network stations. (Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.) On September 1, 1961, weekly determinations of gross beta activity again were initiated to permit rapid evaluation of fallout effects from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once monthly except where variable or high values observed during the first year indicated the need for more frequent measurement.

Normally, samples are counted at the Network laboratory within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample that shows unusually high activity during the first analysis. Also if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not corrected by extrapolation to the time of collection.

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (7). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred filter membrane) for counting in an internal proportional counter. Since the fourth quarter of 1958, strontium-90 analyses have been made on three-month composites of aliquots from weekly samples. Therefore strontium-90 results will be presented on a quarterly basis. Until the fourth quarter of 1961, the method used for determining strontium-90 was that described in the aforementioned reference (*7*). Tributylphosphate was used to extract ingrown yttrium-90 from the purified, coprecipitated strontium-90. Since that time, a modification of a procedure described by Harley has been used (*8*). The yttrium-90, together with an yttrium carrier is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background, anticoincidence, end-window proportional counter.

Table 1 presents February 1963 results of alpha and beta analyses of U.S. raw surface waters. These data are preliminary; reanalysis of some samples may be made and additional analyses, not completed at the time of this report, may become available. For final data one should consult the Network's *Annual Compilation of Data* (*6*). The figures for gross alpha and gross beta radioactivity represent determinations made on composite samples or means of weekly determinations where composites were not made.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the total beta activity in suspended-plus-dissolved-solids in raw water collected at that station. Network results for the years 1957–1962 have been summarized by Weaver et al (9).

REFERENCES

(1) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data*, PHS Publication No. 663, 1958 Edition, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

(2) Ibid., 1959 Edition.

(3) Ibid., 1960 Edition.

(4) Ibid., 1961 Edition.

(5) Ibid., 1962 Edition (in press).

(6) Ibid., 1963 Edition (to be published).

(7) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).

(8) Harley, J. H.: Radiochemical Determination of Strontium-90, *Health and Safety Laboratory Manual of Standard Procedures*, August 1962 Revision, Radiochemistry and Environmental Studies Division, U. S. Atomic Energy Commission, New York Operations Office (1962).

(9) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957–1962, *Radiological Health Data*, 4:306–16, Superintendent of Documents, Government Printing Office, Washington 25, D. C. (June 1963).

Radionuclide Analyses of Coast Guard Water Supplies

May 1962–December 1962

U.S. Coast Guard and Division of Radiological Health, Public Health Service

From 1957 through 1960, monthly samples of several U.S. Coast Guard light station cistern supplies were routinely analyzed for beta activity by the Robert A. Taft Sanitary Engineering Center (1). Low radioactivity concentrations two years after the 1958 cessation of nuclear weapons testing led to the termination of this sampling procedure.

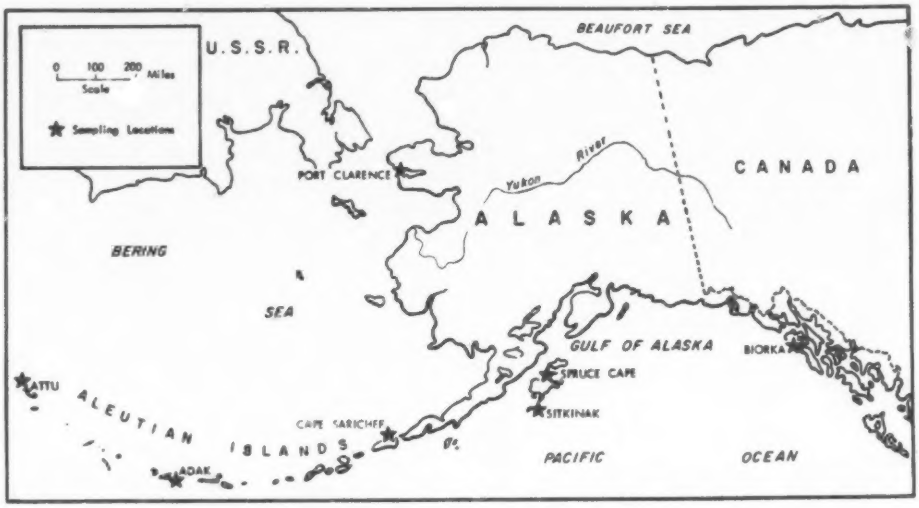

FIGURE 1.—COAST GUARD LORAN STATION WATER SAMPLING LOCATIONS

TABLE 1.—RADIONUCLIDES IN WATER SAMPLES FROM U. S. COAST GUARD LORAN STATIONS, MAY 1962—DECEMBER 1962

[Concentrations in pc/liter]

Alaskan location	1962 Collection date	Gross alpha	Gross beta	Sr^{90}	Ra^{226}	I^{131}	Ba^{140}	Cs^{137}	Zr^{95}
Adak	May 11	5.4	9400	106	[a]—	<10	10	< 5	2300
Attu	May 11	[b]ND	45	2.0	—	<10	45	< 5	50
	May 22	ND	29	2.4	0.1	<10	10	< 5	30
	June 29	1.2	15	0.8	—	<10	<10	< 5	35
	August 10	1.9	7	0.5	0.2	<10	<10	< 5	<10
	September 8	ND	13	0.7	—	<10	<10	< 5	<10
	October 9	ND	13	1.6	1.5	40	20	< 5	<10
	November 13	ND	7	1.0	ND	<10	<10	< 5	<10
	December 8	1.4	26	—	—	<10	<10	< 5	<10
Biorka	May 8	2.1	57	1.6	—	<10	<10	< 5	60
	June 14	1.4	53	2.3	—	<10	20	< 5	20
	July 17	Lost	Lost	9.8	ND	<10	50	<10	10
	August 14	ND	9	3.3	—	<10	<10	< 5	10
	September 8	0.5	45	0.8	—	<10	<10	< 5	< 5
	October 9	ND	87	0.2	ND	<10	<10	< 5	< 5
	November 12	0.6	10	2.0	ND	<10	90	< 5	50
	December 13	ND	80	—	—	<10	110	< 5	< 5
Cape Sarichef	May 12	0.6	12	0.4	—	<10	<10	< 5	< 5
	June 20	ND	96	1.0	—	<10	<10	< 5	< 5
	July 14	ND	5	ND	ND	20	<10	15	<10
	August 14	ND	ND	ND	0.5	50	90	90	<10
	September 9	ND	5	0.1	—	<10	<10	< 5	<10
	October 9	ND	ND	1.9	ND	<10	<10	< 5	<10
	November 9	ND	4	1.0	ND	<10	<10	< 5	<10
	December 21	0.8	14	—	—	200	<10	110	<10
Port Clarence	May 17	1.1	0.8	0.4	—	<10	<10	< 5	< 5
	June 4	ND	4	0.4	—	<10	<10	< 5	<10
	June 15	ND	34	Lost	ND	<10	<10	< 5	< 5
	August 15	3.3	10	0.9	—	<10	<10	< 5	<10
	September 13	0.6	9	2.3	—	<10	<10	< 5	<10
	October 6	0.5	12	ND	—	90	180	20	< 5
	November 7	1.1	13	ND	ND	<10	<10	< 5	<10
	December 15	ND	13	—	—	<10	<10	< 5	<10
Sitkinak	May 15	0.8	20	1.1	—	<10	<10	< 5	< 5
	June 20	ND	60	22.1	—	<10	<10	< 5	< 5
	July 19	0.7	14	1.9	ND	<10	<10	5	<10
	August 28	ND	10	0.8	ND	40	<10	< 5	<10
	October 22	ND	11	1.0	ND	<10	<10	< 5	<10
	November 13	ND	11	ND	ND	<10	<10	< 5	<10
	December 10	0.7	34	ND	ND	<10	<10	< 5	<10
Spruce Cape	May 8	0.9	19	1.2	—	<10	35	< 5	< 5
	June 13	0.8	23	1.2	0.1	<10	15	< 5	10
	July 10	1.7	3	0.3	—	<10	10	< 5	15
	August 12	0.8	18	[c]IS	IS	<10	<10	< 5	<10
	August 16	ND	8	1.4	0.4	<10	<10	< 5	<10
	October 11	ND	16	ND	ND	<10	<10	< 5	<10
	November 6	0.8	11	ND	ND	<10	60	< 5	<10
	December 11	ND	113	—	—	<10	<10	< 5	40

[a] Dash indicates results not reported.
[b] ND indicates activity not detectable.
[c] IS indicates insufficient sample.

Since October 1961, drinking water samples have been obtained from Coast Guard Loran Stations in Alaska. In most cases, these samples are collected from small artificial impoundments or lakes. The sampling sites are shown in figure 1.

The radionuclide analyses reported in table 1 were performed by the Southwestern Radiological Health Laboratory at Las Vegas, Nevada. Previous results were last reported in *Radiological Health Data*, October 1962.

REFERENCE

(1) Straub, C. P.: Statement on New Data on Uptake in Milk, Food, and Human Bone, *Joint Committee on Atomic Energy Hearings on Fallout From Nuclear Weapons Tests*, 2:990 (May 1959).

Previous coverage in *Radiological Health Data:*

Period	*Issue*
October–November 1959	*June 1960*
October–December 1959	*July 1960*
Fourth quarter 1959, First and second quarters 1960	*August 1961*
October 1961-April 1962	*October 1962*

SECTION V.—OTHER DATA

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission regularly receives reports from its contractors on the environmental levels of radioactivity in the vicinity of major Commission installations. These reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have periodically appeared in *Radiological Health Data* since November 1960. A summary of the Savannah River Plant report for calendar year 1962 follows.

Savannah River Plant

Calendar Year 1962

E. I. du Pont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP) maintains a continuous monitoring program to determine the concentrations of radioactive materials in a 1200-square-mile area outside the plant perimeter. Included in this area are parts of Aiken, Barnwell, and Allendale Counties in South Carolina and Richmond, Burke, and Screven Counties in Georgia. This program, initiated in 1951 prior to plant operations, is carried out by the Health Physics Section of E. I. du Pont de Nemours and Company, prime contractor for operation of the plant for the Atomic Energy Commission.

Although SRP discharges some gaseous and liquid waste to the environment, the releases are controlled to assure adequate dispersal so that the offsite concentration of radioactive materials is below the Radioactivity Concentration Guides (RCG's)* shown in table 1. Continuous surveillance of the Savannah River Plant provides information useful both as a measure of the effectiveness of plant controls and as evidence of the strict adherence to the recommended RCG.

Atmospheric Monitoring

Continuous air and rainwater samples are collected at 15 monitoring stations. These stations, which include 5 locations (A—E) at the plant perimeter and 10 locations approximately 25 miles from the center of the plant are spaced so that a measurable plant release of radioactivity to the air would be detected regardless of prevailing wind conditions (see figure 1). Four additional air monitoring stations are operated approximately 100 miles from the plant at Savannah and Macon, Georgia, and Columbia and Greenville, South

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* The Radioactivity Concentration Guide (RCG)—a frame of reference against which environmental contamination levels can be compared—is the concentration in the environment (air, drinking water, and food) which is determined to result in organ doses equal to the recommended Radiation Protection Guide (RPG) levels. The Radiation Concentration Guides used in this report are based on the permissible concentrations recommended by the National Committee on Radiation Protection (NCRP) and the recommendations of the Federal Radiation Council.

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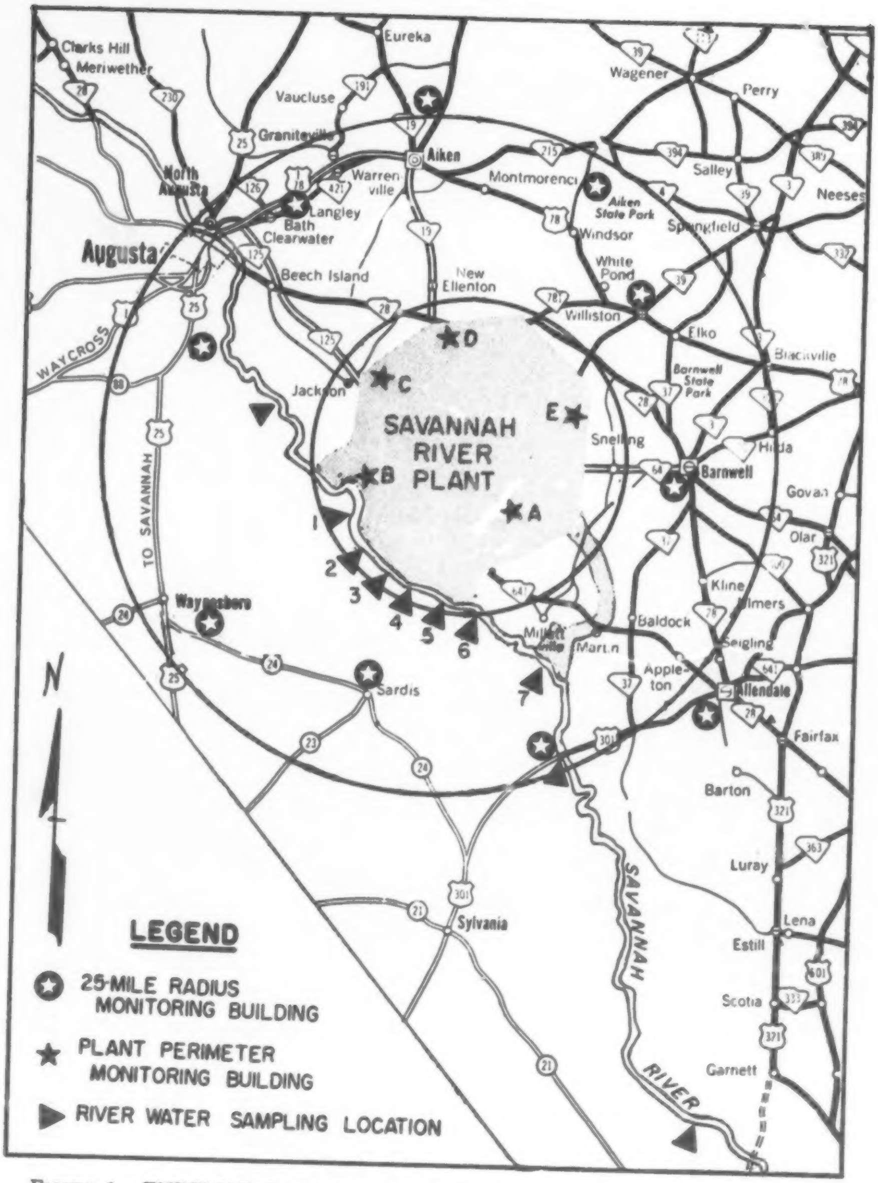
Clarks Hill
Meriwether
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Langley
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Clearwater
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Beech Island
New Ellenton
Windsor
White Pond
Williston
Wagener
Perry
Salley
Neeses
Aiken State Park
Springfield
Elko
Blackville
Barnwell State Park
WAYCROSS
Jackson
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Seigling
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Millettville
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Allendale
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Scotia
Garnett
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25-MILE RADIUS MONITORING BUILDING
PLANT PERIMETER MONITORING BUILDING
RIVER WATER SAMPLING LOCATION

FIGURE 1.—ENVIRONMENTAL SAMPLING LOCATIONS, SAVANNAH RIVER PLANT

Carolina (see figure 2). At this distance, the effect of SRP operations is minimal, and, therefore, these facilities serve as "reference points" for determining background levels of activity. The complete system of 19 stations permits a comprehensive surveillance of atmospheric radioactivity and differentiation between weapons testing fallout and plant releases. The average concentrations of radioactivity in air and rainwater are given in tables 2 and 3.

The levels of radioactivity observed in air and in rainwater were attributed to fallout, as the radioactivity concentrations showed no correlation to plant releases.

TABLE 1.—RADIOACTIVITY CONCENTRATION GUIDES USED BY THE SAVANNAH PLANT

Measurement	RCG
Radioactivity in air	
alpha emitters	0.04 pc/m³
nonvolatile beta emitters	100 pc/m³
iodine–131	100 pc/m³
Radioactivity in rainwater[a]	
alpha emitters	10 pc/liter
nonvolatile beta emitters	3,000 pc/liter
iodine–131	100 pc/liter
Radioactivity in milk	
tritium	300,000 pc/liter
iodine–131	100 pc/liter
strontium–90	100 pc/liter
Radioactivity in public water supplies	
alpha emitters	10 pc/liter
nonvolatile beta emitters	3,000 pc/liter
Radioactivity in Savannah River water	
alpha emitters	10 pc/liter
nonvolatile beta emitters	3,000 pc/liter
tritium	300,000 pc/liter
strontium–90	90 pc/liter

[a] Assuming use as drinking water.

TABLE 2.—RADIOACTIVITY IN AIR

[Average concentrations in pc/m³]

Period	Source of samples	Alpha	Non-volatile beta	Iodine-131
First half 1962	plant perimeter	0.0008	3.9	*
	25-mile radius	0.0008	3.9	*
	100-mile radius	0.0010	3.9	*
Second half 1962	plant perimeter	0.0007	3.3	0.07
	25-mile radius	0.0008	3.4	0.06
	100-mile radius	0.0011	3.9	0.07

* Below the minimum detection limits (0.02 pc/m³).

TABLE 3.—RADIOACTIVITY IN RAINWATER

[Average concentrations in pc/liter]

Period	Source of samples	Alpha	Non-volatile beta	Iodine-131
First half 1962	plant perimeter	0.4	1,400	*
	25-mile radius	0.3	1,300	*
Second half 1962	plant perimeter	0.4	820	36
	25-mile radius	0.4	920	29

* Below the minimum detection limits (9 pc/liter).

Milk

Milk samples were collected from dairies and farms within a 50-mile radius of the Plant, and were analyzed weekly for tritium and iodine–131 and monthly for strontium–90. Average concentrations of tritium, iodine–131 and strontium–90 are given in table 4.

The estimated exposure to a child's thyroid for calendar year 1962 from consumption of one liter of local dairy milk per day was less than 25 percent of the 0.5 rem per year guidance value suggested by the Federal Radiation Council. The exposure to an adult would be one-tenth that of a child on a thyroid weight basis.

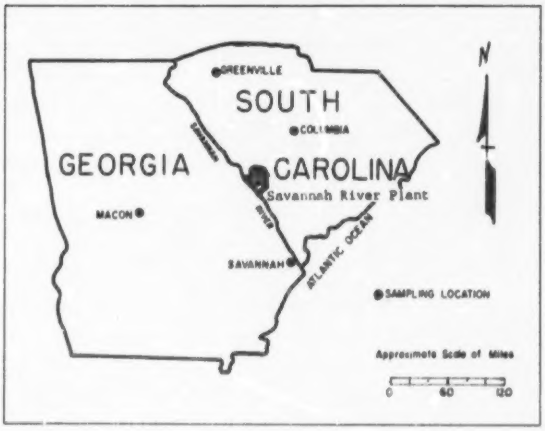

FIGURE 2.—DISTANT AIR MONITORING STATIONS, SAVANNAH RIVER PLANT

TABLE 4.—RADIOACTIVITY IN MILK

[Average concentrations in pc/liter]

Analysis	Number of locations	First half 1962	Second half 1962
Tritium			
Farms	4	6,000	5,000
Local dairies	6	4,000	4,000
Major distributors	1	3,000	3,000
Iodine-131			
Farms	4	11	87
Local dairies	6	7	27
Major distributors	1	<6	24
Strontium-90			
Farms	5	48	43
Local dairies	6	19	16
Major distributors	3	19	16

The higher concentrations of strontium–90 in milk of farm cows were attributed to the feeding habits. These cows generally received little commercial feed but grazed on topshoots or shallow-rooted grasses, both susceptible to fallout contamination. Dairy cows, on the other hand, received less pasture grass and more dried silage and commercial feed. The same relationship seems to be true for tritium and iodine–131.

Vegetation

Bermuda grass, because of its importance as a pasture grass for dairy herds and its year-round availability, was selected for analysis of radioactive contamination.

Average concentrations of alpha emitters and nonvolatile beta emitters found on vegetation collected at the air monitoring locations shown in figure 2 are summarized in table 5.

TABLE 5.—RADIOACTIVITY IN VEGETATION (BERMUDA GRASS)

[Average concentrations in pc/gm]

Period	Source of sample	Alpha	Non-volatile beta
First half 1962	Plant perimeter	0.18	290
	25-mile radius	0.18	320
Second half 1962	Plant perimeter	0.10	90
	25 mile radius	0.08	80

Algae and Fish in Savannah River

Determination of radioactivity concentrations in algae is important because algae are concentrators of specific radionuclides and also have an important relationship in the food chain of aquatic organisms. Indigenous algae samples were collected weekly upstream from, adjacent to, and downstream from the plant. The average nonvolatile beta concentrations are given in table 6. Some correlation of plant effluent entry into the river is indicated by the lower upstream values Fish taken from the river showed negligible plant-contributed radioactivity.

TABLE 6.—NONVOLATILE BETA IN SAVANNAH RIVER ALGAE AND FISH

[Average concentration in pc/gm]

Period	Location	Nonvolatile beta	
		Algae	Fish (flesh)
First half 1962	Adjacent to plant	165	5
	Upstream (3 mi.)	100	4
	Downstream (10 mi.)	135	4
Second half 1962	Adjacent to plant	445	8
	Upstream (3 mi.)	45	4
	Downstream (10 mi.)	140	6

Water Monitoring

Communities in the vicinity of SRP obtain water from deep wells or surface streams. Public water samples are collected monthly from 14 surrounding towns. The Savannah River is sampled continuously at 7 locations. Six of the locations are shown in figure 1; the seventh is 60 miles downstream from the plant.

Average concentrations of alpha and beta activity in public and Savannah River water are presented in table 7. The values shown indicate that plant operations contribute small amounts of radioactivity to the Savannah River, and the resulting concentrations are far below RCG values.

TABLE 7.—RADIOACTIVITY IN WATER

[Average concentrations in pc/liter]

Period	Source of samples	Alpha	Non-volatile beta	H^3	Sr^{90}
First half 1962.	Public water supplies	1.2	10	—	—
	Savannah River water				
	3 miles upstream	0.3	38	*	0.8
	10 miles downstream	0.2	52	7, 500	1.2
Second half 1962.	Public water supplies	1.2	7	—	1.2
	Savannah River water				
	3 miles upstream	0.1	12	710	0.8
	10 miles downstream	0.1	35	13, 000	1.7

* Less than sensitivity of analysis (600 pc/liter).

External Gamma Radiation Levels

Environmental gamma radiation levels are measured by portable ion chamber dosimeters at each of the 15 air monitoring stations shown in figure 1. The average gamma radiation doses for calendar year 1962 were 0.44 mr per 24 hours at the plant perimeter stations and 0.42 mr per 24 hours at the 25 mile radius stations.

Discussion

During 1962, the low levels of radioactivity released to the environs by the SRP were for the most part too low to be distinguished from natural background radiation levels, or were obscured by world-wide fallout from nuclear weapons testing.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*May 1961*
Fourth quarter 1960	*August 1961*
First and second quarters 1961	*February 1962*
Third and fourth quarters 1961	*September 1962*

Whole Body Counting

Whole body counters are being applied where the detection of low levels of radioactivity in the human body is of prime interest. One example is the evaluation of hazards to radiation workers and the general population. These instruments are also used in human physiological and pathological investigations as well as in studies related to counter design for special purposes. Discussion and presentation of whole body counting results in previous issues of *RHD* have been limited to medical research programs employing thallium-activated sodium iodide crystals or liquid scintillation solutions.

CESIUM-137 IN MAN

September 1962 through December 1962

U.S. Army Medical Research Unit, Landstuhl, Germany

In 1955, cesium-137 was first detected in man by the Argonne National Laboratory (*1*). It emits a 0.661 Mev gamma photon, which can be quantitatively determined by a properly calibrated whole body counter. Since cesium is physiologically similar to potassium, and for the most part exists intracellularly, the cesium-137 levels are usually expressed in picocuries per gram of potassium. The whole body counting facility at the Medical Research Unit, Landstuhl, Germany, in its program for measuring the cesium-137 levels in man, utilizes a liquid scintillation counter (*2*). Results of analyses performed at Landstuhl from September through December 1962 are presented in table 1 and appear in figure 1 together with similar data collected since July 1960.

TABLE 1.—ASSAYS PERFORMED AT THE U. S. ARMY MEDICAL RESEARCH UNIT LANDSTUHL, GERMANY

Date	Number of subjects	Residence	Cesium-137 pc/g K (average)	Percent MPBB[1]
September 1962	381	West Germany	51	0.24
October 1962	238	West Germany	61	0.28
November 1962	606	West Germany	52	0.24
December 1962	110	West Germany	49	0.22

[1] Percent maximum permissible body burden was calculated using 3 μc of cesium-137 as the general population maximum permissible whole body burden and 140 grams of potassium in the body of the "standard man." (See pp. 187 and 192 of Radiological Health Handbook, Office of Technical Services, U. S. Department of Commerce (1960), price $3.75.)

REFERENCES

(*1*) Miller, C. E., and L. D. Marinelli: Gamma-Ray Activity of Contemporary Man, *Science*, *124*:122–3 (20 July 1956).

(*2*) Anderson, E. C., F. N. Hays, and R. D. Hiebert: Walk-in Human Counter, *Nucleonics*, *16*:106 (August 1958).

Recent coverage in *Radiological Health Data:*

Period	*Issue*
First quarter 1961	*July 1961*
Second quarter 1961	*October 1961*
Third quarter 1961	*January 1962*
First quarter 1962	*August 1962*
Second quarter 1962	*October 1962*
Third quarter 1962	*December 1962*
July 1958–September 1962	*April 1963*

U.S. PUBLIC HEALTH SERVICE
* 1798 *

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SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Early indications of possible fission product activity fluctuations in other phases of the environment are being secured through the continuous surveillance of gross beta activity in air and precipitation. The information obtained through this form of surveillance does not by itself permit evaluation of biological effects due to fallout, but it does form the basis for an alerting system and can be used as a guide for determining when and where more extensive monitoring of radioactivity in food, milk, and water is desirable.

In this section, gross beta concentrations for May 1963 are presented in reports from the Radiation Surveillance Network and the Canadian Radioactive Fallout Study Program. Network intercalibration factors, determined by Lockhart and Patterson (*1*), were used in constructing the isogram map (fig 4), which presents data on Canadian and U.S. gross beta radioactivity in air for April. To adjust the data from the two networks to a common baseline, the U.S. data were multiplied by a factor of 1.54, the U.S.-Canadian intercalibration factor suggested by the NRL study. Also included are air data collected by the Pan American Sampling Program during the period November 1962–May 1963.

REFERENCE

(*1*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Washington, D.C. (November 13, 1962); abstracted in *Radiological Health Data*, December 1962.

RADIATION SURVEILLANCE NETWORK
May 1963

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) comprises 72 sampling stations distributed throughout the United States (see figure 1). Most of these stations are manned by State health department personnel.

Air

Daily 24-hour air samples are collected on a 4-inch diameter, carbon-loaded cellulose dust filter in a high-volume air sampler. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}–Y^{90} source of known activity. This determination is usually made about 5 hours after the end of the sampling period to eliminate interference from naturally occurring radon daughters. The Network's station operators report their field estimates daily by telephone to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. From this information, a daily national report is prepared.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window, gas-flow proportional counter, calibrated with a 40,000-pc Sr^{90}–Y^{90} standard. Each filter is counted at least 3 days after the end of the sampling period and is re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally occurring radon and thoron daughters. From the two counts, which are separated by the 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula: $AT^{1.2} = \text{constant}$ (*1*) [1] the daily

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[1] In this expression, A is the activity and T is the time after fission product formation.

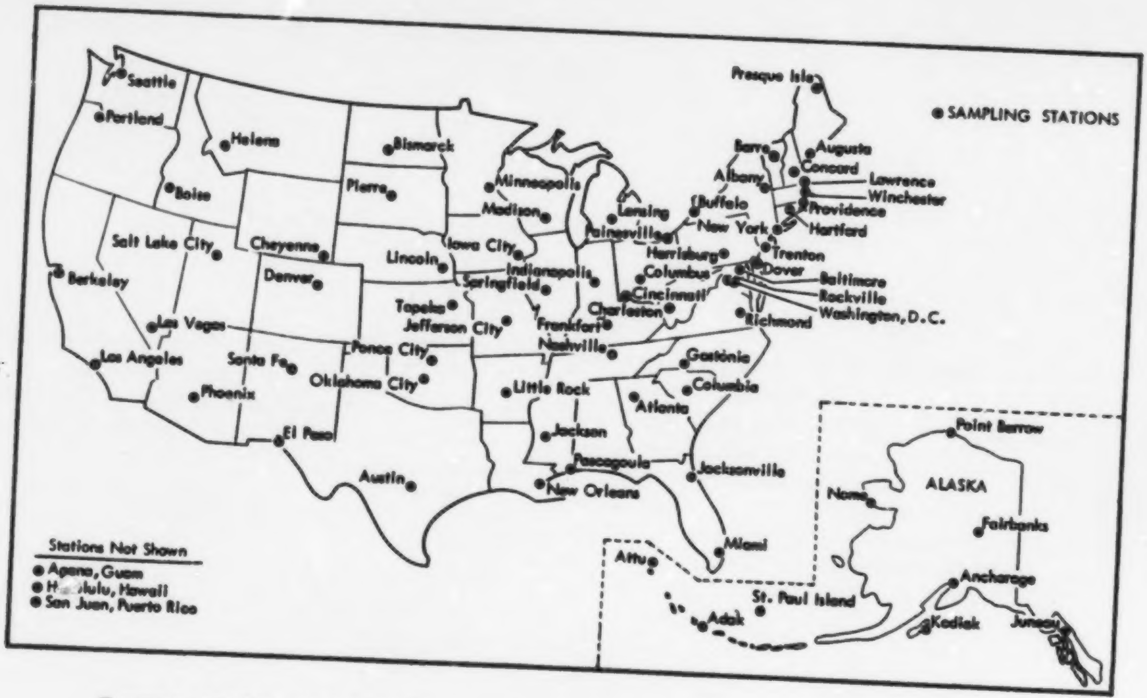
● SAMPLING STATIONS
Seattle
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Presque Isle
Barre
Augusta
Concord
Lawrence
Winchester
Albany
Providence
Hartford
Buffalo
Lansing
New York
Painesville
Trenton
Harrisburg
Dover
Columbus
Baltimore
Rockville
Washington, D.C.
Cincinnati
Charleston
Richmond
Salt Lake City
Cheyenne
Lincoln
Iowa City
Indianapolis
Springfield
Berkeley
Denver
Topeka
Jefferson City
Frankfort
Las Vegas
Nashville
Ponca City
Gastonia
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Columbia
Phoenix
Atlanta
El Paso
Jackson
Point Barrow
Pascagoula
Jacksonville
Austin
New Orleans
Nome
ALASKA
Fairbanks
Miami
Attu
Anchorage
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, MAY 1963

concentrations and estimated age are reported by the PHS in a monthly RSN report (*2*).

The average fission product beta concentrations in surface air during May 1963, as determined by laboratory analysis and extrapolated to the time of collection, are given in table 1. These data (adjusted by the intercalibration factor 1.54), [2] together with corresponding Canadian data, are represented by isogram lines in figure 4 which show the distribution of fission product activity over most of North America.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meters. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples, including extrapolation to the time of collection. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made. May 1963 averages of gross beta activity in precipitation, expressed in picocuries per liter (cp/liter) and nanocuries per square meter (nc/m^2), are presented in table 2.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in *RHD*, July 1961. The profiles of 7 stations, from 1957 through May 1963, are shown in figure 2.

REFERENCES

(*1*) Way, K., and E. P. Wigner: The Rate of Decay of Fission Products, *Physics Review, 73:* 1318–30 (June 1948).

(*2*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington 25, D.C. (Distribution by official request).

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[2] See reference (*1*) on page 431.

TABLE 1.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, RSN, MAY 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average[a]
Alaska:	Adak	31	10	<0.10	2.4
	Anchorage	30	8.2	0.36	3.0
	Attu	31	11	0.14	4.0
	Fairbanks	23	12	0.61	4.2
	Juneau	26	15	0.40	4.7
	Kodiak	29	9.2	0.10	2.41
	Nome	18	6.8	0.10	2.2
	Point Barrow	18	9.1	1.6	3.7
	St. Paul Island	28	5.5	<0.10	2.0
Ariz:	Phoenix	30	17	4.9	9.7
Ark:	Little Rock	29	15	5.3	9.7
Calif:	Berkeley	29	8.2	0.44	3.7
	Los Angeles	22	16	1.7	6.0
Colo:	Denver	27	22	1.8	9.2
Conn:	Hartford	30	12	1.5	5.8
Del:	Dover	22	15	1.7	8.1
D.C:	Washington	31	11	2.1	6.4
Fla:	Jacksonville	29	15	2.5	7.5
	Miami	26	13	2.8	7.0
Ga:	Atlanta	23	13	2.6	7.2
Guam:	Agana	12	4.9	<0.10	1.1
Hawaii:	Honolulu	29	9.9	1.6	3.7
Idaho:	Boise	30	17	1.0	9.6
Ill:	Springfield	29	11	1.4	6.1
Ind:	Indianapolis	27	18	0.84	7.5
Iowa:	Iowa City	28	12	0.71	5.4
Kans:	Topeka	30	11	3.3	6.8
Ky:	Frankfort	30	13	2.4	6.9
La:	New Orleans	31	12	3.2	7.1
Maine:	Augusta	30	16	1.8	6.9
	Presque Isle	31	12	1.1	6.0
Md:	Baltimore	22	8.5	2.3	5.2
	Rockville	15	12	2.0	6.2
Mass:	Lawrence	30	14	2.1	7.1
	Winchester	27	19	1.7	7.9
Mich:	Lansing	31	13	0.54	7.6
Minn:	Minneapolis	30	13	0.18	6.2
Miss:	Jackson	29	12	3.3	7.4
	Pascagoula	19	13	2.2	7.3
Mo:	Jefferson City	30	11	0.90	5.7
Mont:	Helena	30	14	1.8	7.3
Nebr:	Lincoln	19	17	1.2	6.0
Nev:	Las Vegas	28	29	6.1	14
N.H:	Concord	21	18	1.9	8.5
N.J:	Trenton	31	11	1.5	5.8
N. Mex:	Santa Fe	31	14	1.6	7.1
N.Y:	Albany	29	11	1.1	6.5
	Buffalo	17	17	2.3	8.9
	New York	18	12	1.6	5.3
N.C:	Gastonia	31	11	2.1	6.6
N. Dak:	Bismarck	30	13	0.25	6.5
Ohio:	Cincinnati	22	10	1.1	6.5
	Columbus	30	16	2.1	7.4
	Painesville	29	22	2.0	9.6
Okla:	Oklahoma City	31	9.3	4.5	6.2
	Ponca City	29	8.7	2.2	4.7
Ore:	Portland	29	24	3.4	9.4
Pa:	Harrisburg	27	11	1.4	5.2
P.R:	San Juan	29	4.5	0.72	2.6
R.I:	Providence	30	13	1.1	6.8
S.C:	Columbia	27	11	1.6	6.5
S. Dak:	Pierre	30	10	1.1	5.2
Tenn:	Nashville	30	18	1.8	8.5
Tex:	Austin	30	11	3.0	7.1
	El Paso	30	12	2.4	6.7
Utah:	Salt Lake City	31	15	2.3	8.1
Vt:	Barre	29	14	0.40	6.8
Va:	Richmond	31	11	1.8	5.4
Wash:	Seattle	31	9.8	1.0	4.3
W.Va:	Charleston	31	10	1.4	5.7
Wisc:	Madison	31	20	0.39	9.4
Wyo:	Cheyenne	29	12	3.6	7.5
Network			29	<0.10	6.37

[a] Averages are weighted by lengths of sampling times.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, MAY 1963

Station location		Average concentration (pc/liter)	Total deposition (nc/m²)
Alaska:			
	Anchorage	1,300	6
	Fairbanks	[a]—	—
	Juneau	1,400	100
Ark:	Little Rock	1,100	23
Calif:	Berkeley	580	5.8
	Los Angeles	—	—
Colo:	Denver	7,700	67
Conn:	Hartford	2,700	180
D.C:	Washington	3,600	110
Fla:	Jacksonville	2,400	100
	Miami	870	80
Ga:	Atlanta	—	—
Idaho:	Boise	2,400	61
Ill:	Springfield	920	39
Ind:	Indianapolis	2,200	100
Iowa:	Iowa City	2,600	120
Kans:	Topeka	2,200	230
Ky:	Frankfort	2,200	140
La:	New Orleans	1,600	27
Maine:	Augusta	1,900	200
	Presque Isle	1,500	110
Md:	Baltimore	3,600	36
Mass:	Lawrence	4,100	440
	Winchester	2,100	180
Mich:	Lansing	2,400	130
Minn:	Minneapolis	2,000	260
Miss:	Jackson	—	—
Mo:	Jefferson City	3,100	460
Mont:	Helena	3,200	100
Nebr:	Lincoln	2,700	140
Nev:	Las Vegas	—	—
N.J:	Trenton	2,700	119
N. Mex:	Santa Fe	2,300	29
N.Y:	Albany	2,100	64
	Buffalo	—	—
N.C:	Gastonia	890	49
N. Dak:	Bismarck	3,700	250
Ohio:			
	Columbus	2,000	110
	Painesville	3,200	130
Okla:	Oklahoma City	1,100	11
	Ponca City	1,400	86
Ore:	Portland	1,300	60
Pa:	Harrisburg	1,400	92
P.R:	San Juan	540	42
R.I:	Providence	2,100	260
S.C:	Columbia	3,200	45
S. Dak:	Pierre	2,100	34
Tenn:	Nashville	2,800	92
Tex:	Austin	2,300	66
	El Paso	—	—
Utah:	Salt Lake City	2,600	6.4
Vt:	Barre	2,700	120
Va:	Richmond	1,200	74
Wash:	Seattle	1,900	16
W.Va:	Charleston	2,100	180
Wisc:	Madison	2,500	93
Wyo:	Cheyenne	4,500	60

[a] Dash indicates no evaporated sample received.

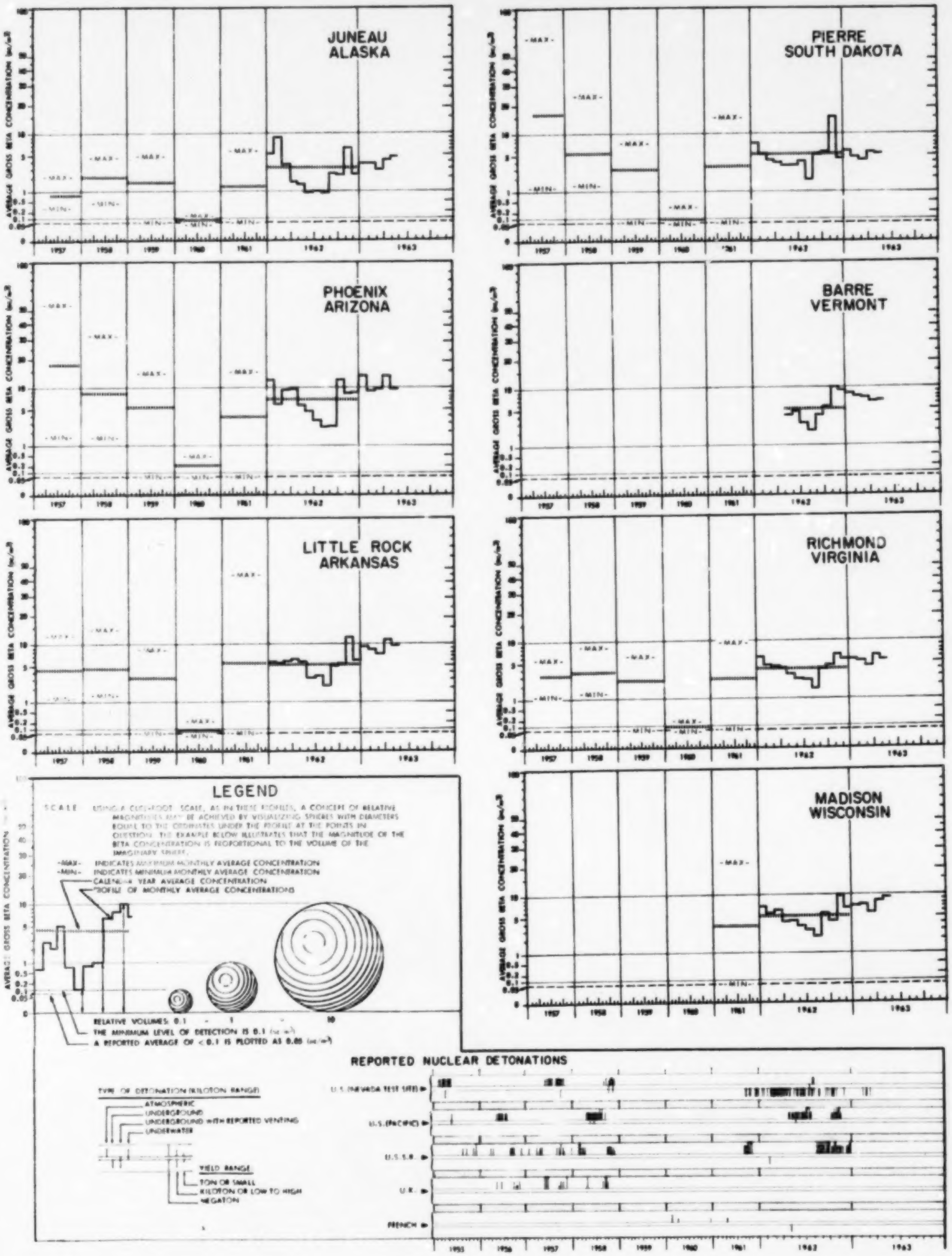

Figure 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1957–May 1963

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CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM
May 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four RFSP collection stations are located at airports (see figure 3) where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter, system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurments are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for May 1963 are given in table 3 and presented in conjunction with U.S. adjusted air data by the isogram map (figure 4).

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, RFSP, MAY 1963
[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	31	24.3	4.6	13.8
Coral Harbour	31	15.5	0.9	6.7
Edmonton	31	27.0	6.0	11.9
Ft. Churchill	29	12.3	2.8	7.0
Ft. William	31	24.1	2.0	11.0
Fredericton	29	23.0	0.5	10.6
Goose Bay	31	15.7	2.4	9.2
Halifax	29	22.0	2.0	10.0
Inuvik	31	20.0	0.7	7.0
Montreal	31	28.0	3.0	15.8
Moosonee	31	24.0	1.2	11.8
Ottawa	31	23.0	1.3	14.2
Quebec	31	26.0	3.7	13.4
Regina	30	23.3	2.8	13.0
Resolute	30	12.9	3.5	7.4
St. John's	30	15.9	0.7	6.6
Saskatoon	31	26.0	2.5	13.5
Sault Ste. Marie	30	25.5	5.2	13.2
Toronto	31	21.5	0.2	11.8
Vancouver	31	24.1	2.9	9.8
Whitehorse	31	30.2	2.0	12.1
Windsor	31	25.2	2.7	13.0
Winnipeg	30	27.2	1.6	12.6
Yellowknife	30	21.0	2.2	11.2
Network		30.2	0.2	11.1

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on

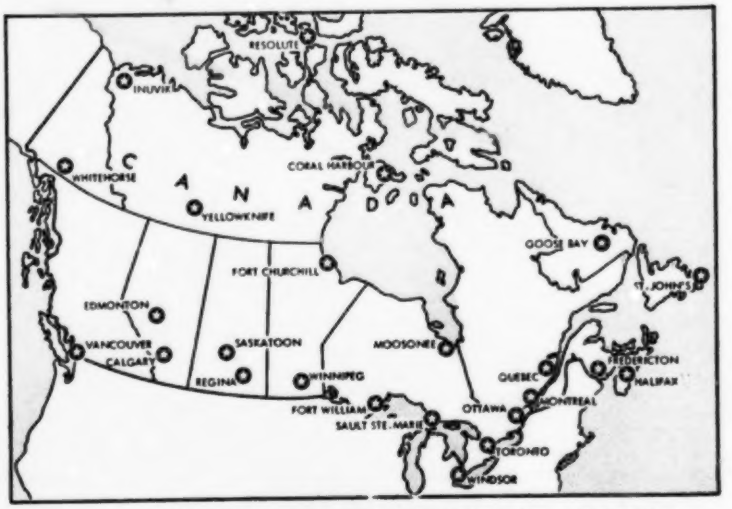

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS, MAY 1963

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, RFSP, MAY 1963

Station	Total beta activity	
	pc/liter	mc/km²
Calgary	b	86.3
Coral Harbour	b	116
Edmonton	5,890	190
Ft. Churchill	1,980	51.5
Ft. William	6,040	380
Fredericton	2,750	193
Goose Bay	2,490	123
Halifax	3,940	414
Inuvik	b	63.9
Montreal	2,640	233
Moosonee	3,580	311
Ottawa	2,620	200
Quebec	3,020	266
Regina	4,790	276
Resolute	680	36.2
St. John's	2,170	234
Saskatoon	4,670	194
Sault Ste. Marie	3,050	246
Toronto	2,970	206
Vancouver	1,315	60.1
Whitehorse	a	a
Windsor	3,800	238
Winnipeg	5,030	341
Yellowknife	b	52.5
Average	3,340	196

a No sample.
b Trace precipitation.

material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample, and sent to the laboratory. May precipitation data for Canada are shown in table 4.

REFERENCES

(1) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW-RP-3*, Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4*, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) Mar, P. G.: *Annual Report for 1961 on the Radioactive Fallout Study Program CNHW-RP-5*, Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) Beale, J. and J. Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program, RPD-11*, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RPD-21*, Department of National Health and Welfare, Ottawa, Canada (August 1962).

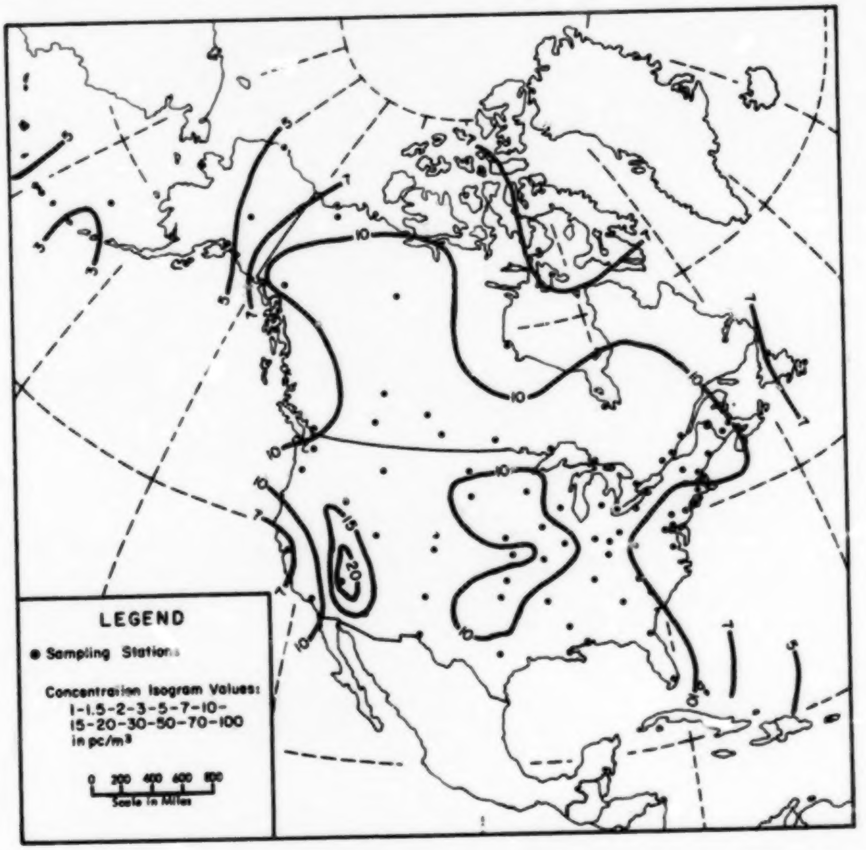

FIGURE 4.—AIRBORNE GROSS BETA CONCENTRATION ISOGRAM VALUES FOR CANADA AND THE U.S., MAY 1963

PAN AMERICAN SAMPLING PROGRAM
Novembery–May 1963

Pan American Health Organization and
Public Health Service

Gross beta activity in air is being monitored at three locations in the Americas under a collaborative radiological health program between the Pan American Health Organization (PAHO) and the Public Health Service (PHS).

The three air sampling stations presently included in the program are located in Santiago, Chile; Lima, Peru; and Caracas, Venezuela. The Caracas station was activated in November 1962 and the other two stations entered in December.

The air sampling stations are manned by local personnel and the sampling equipment and laboratory analyses are provided by the Public Health Service. Equipment and counting procedures are identical with those employed for the Radiation Surveillance Network.

Fission product gross beta activity for the months of November 1962 through May 1963 are presented in table 5.

The higher monthly average values noted for Caracas, in comparison with values for corresponding months for Lima and Santiago, are consistent with the Northern Hemisphere location of the Caracas station.

TABLE 5.—GROSS BETA ACTIVITY IN AIR, PASP

[Concentrations in pc/m³]

Sampling stations Months	No. of samples	Maximum	Minimum	Average
November 1962				
Caracas, Venezuela	20	6.3	0.11	1.2
December 1962				
Caracas, Venezuela	19	4.1	0.12	2.0
Lima, Peru	12	0.50	0.33	0.38
Santiago, Chile	15	0.41	0.14	0.26
January 1963				
Caracas, Venezuela	23	8.9	0.32	2.9
Lima, Peru	5	0.25	0.14	0.19
Santiago, Chile	14	0.41	0.18	0.27
February 1963				
Caracas, Venezuela	20	4.1	1.2	2.2
Lima, Peru	19	0.91	0.12	0.29
Santiago, Chile	15	0.35	0.15	0.24
March 1963				
Caracas, Venezuela	20	4.3	0.25	2.7
Lima, Peru	18	0.23	0.10	0.15
Santiago, Chile	14	0.67	0.16	0.30
April 1963				
Caracas, Venezuela	20	4.6	0.48	1.8
Lima, Peru	14	0.18	0.11	0.14
Santiago, Chile	16	0.29	0.12	0.18
May 1963				
Caracas, Venezuela	21	2.7	0.15	1.2
Lima, Peru	0	—	—	—
Santiago, Chile	10	1.1	0.13	0.27

Fission Product Gamma Activity in Airborne Particulates

THE 80TH MERIDIAN NETWORK
March and April 1963

William R. Collins Jr. [1]

This report covers the data available on gamma activity measurements performed on ground-level air filter samples collected during March and April 1963 from stations near the 80th Meridian (see figure 1). Through the end of March all stations in the Southern Hemisphere continued sampling about 1200 cubic meters of air per day on 8-inch-diameter cellulose asbestos (type 6) filter papers, using the method and equipment previously described by the Naval Research Laboratory.[2] Beginning on March 1 in the Northern Hemisphere and April 1 in the Southern, stations sampled about 1400 cubic meters of air per day on 8-inch-diameter polystyrene (Microsorban) filters using the new methods and equipment selected by Health and Safety Laboratory (HASL). The major changes that have been made in the equipment (see figure 2) are the addition of a pump pressure gage which permits a more accurate calculation of the effect of pressure drop on sample volume and the preset vacuum relief valve which automatically ends the sampling when the pump pressure exceeds 78 inches of water. Minor alterations include adaptation of the filter head to accommodate the Microsorban filter paper and the addition of a noise muffler to the blower.

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[1] Mr. Collins is a staff member of the Health and Safety Laboratory, U.S. Atomic Energy Commission, New York City.

[2] Monthly gross beta averages and profiles of the 80th Meridian Network, Naval Research Laboratory, covering the period from November 1959 through December 1962, were reported monthly in *Radiological Health Data*, April 1960–April 1963. Results of the radiochemical analyses of the air filters for the calendar year 1960 and 1961 were presented in *RHD*, March 1962 and February 1963, respectively.

In all cases, samples were changed when possible on the 1st, 8th, 15th, and 22nd of the month and forwarded to HASL for gamma radiometric and radiochemical analysis. Each sample received was counted approximately two weeks after the midpoint of the sampling period on an 8 x 4 inch sodium iodide (thallium activated) crystal, obtaining both total gamma activity and the fraction of the gamma activity with energies above 1.0 Mev. The ratio of these two values serves as an age indicator (*1*). The results, in terms of gamma photons per minute per cubic meter, are listed in tables 1 and 2. The monthly averages are illustrated in figure 3 as an activity-latitude profile. Total beta activity estimates, obtained by the method described in the January 1963 report (*1*) are also listed in the tables.

Qualitative analysis of the gamma-ray spectra of these samples indicates that significant air con-

TABLE 1.—ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, MARCH 1963

Sampling station	Sampling period (dates—noon to noon)	Gamma activity (photons/min/m³)		Ratio $\left(\frac{\gamma > 1 \text{ Mev}}{\text{total } \gamma}\right)$	Estimated total beta activity
		Filter	Average for month		
Thule	8-15	8.01		0.017	5.4
	15-22	12.5		0.015	8.5
	22-4/1	12.2	10.9	0.017	8.2
Moosonee	1-8	7.28		0.015	4.9
	8-15	10.1		0.019	6.8
	15-22	7.35		0.014	5.0
	22-4/1	9.74	8.68	0.018	6.6
New York	1-8	11.2		0.025	7.6
	8-15	8.90		0.027	6.0
	15-22	8.38		0.021	5.7
	22-4/1	17.0	11.4	0.019	11.5
Washington	1-8	7.70		0.020	5.2
	8-15	7.08		0.021	4.8
	15-22	9.92		0.016	6.7
	22-4/1	14.9	10.4	0.017	10.1
Miami	1-8	9.77		0.020	6.6
	8-15	10.5		0.018	7.1
	15-22	9.15		0.016	6.2
	22-4/1	18.8	12.6	0.018	12.7
Mauna Loa	1-8	6.62		0.019	4.5
	8-15	11.5		0.018	7.8
	15-22	6.94		0.017	4.7
	22-4/1	6.11	7.63	0.018	4.1
San Juan	1-8	6.82		0.020	4.6
	8-15	8.49		0.018	5.7
	15-22	9.15		0.017	6.2
	22-4/1	7.92	8.09	0.018	5.4
Miraflores	1-8	6.87		0.021	4.6
	8-15	6.75		0.017	4.6
	15-22	9.17		0.016	6.2
	22-4/1	11.7	8.84	0.018	7.9
Guayaquil	[a]—	—	—	—	—
Lima	—	—	—	—	—
Chacaltaya	15-22	0.249		0.034	0.17
Antofagasta	1-8	0.211		0.043	0.14
	8-15	0.214		0.025	0.14
	15-22	0.194		0.023	0.13
	22-4/1	0.221	0.210	0.018	0.15
Santiago	1-8	0.276		0.035	0.19
	8-15	0.0816		0.064	0.06
	15-22	0.264		0.039	0.18
	22-4/1	0.260	0.222	0.025	0.18
Puerto Montt	1-8	0.215		0.027	0.14
	8-15	0.317		0.025	0.21
	15-22	0.176		0.036	0.12
	22-4/1	0.279	0.260	0.052	0.19
Punta Arenas	1-8	0.136		0.029	0.09
	8-15	0.127		0.046	0.09
	15-22	0.126		0.015	0.08
	22-4/1	0.219	0.152	0.034	0.15

[a] Data not available.

TABLE 2.—ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, APRIL 1963

Sampling station	Sampling period (dates—noon to noon)	Gamma actiivty (photons/min/M³		Ratio $\left(\frac{\gamma > 1 \text{ Mev}}{\text{total } \gamma}\right)$	Estimated total beta activity (pc/m³)
		Filter	Average for month		
Thule	1-8	8.65		0.018	5.8
	8-15	18.0		0.017	12.2
	15-22	14.1		0.018	9.5
	22-5/1	8.39	12.3	0.020	5.7
Moosonee	1-8	9.63		0.018	6.5
	8-15	7.91		0.018	5.4
	15-22	6.53		0.019	4.4
	22-5/1	5.29	7.35	0.028	3.6
New York	1-8	14.8		0.019	10.0
	8-15	18.1		0.021	12.2
	15-22	14.4		0.019	9.7
	22-5/1	15.2	15.6	0.019	10.3
Washington	1-8	15.9		0.020	10.8
	8-15	11.1		0.017	7.5
	15-22	19.9		0.019	13.5
	22-5/1	10.7	14.4	0.020	7.2
Miami	1-8	17.2		0.018	11.6
	8-15	16.0		0.019	10.8
	15-22	26.8		0.019	18.1
	22-5/1	15.6	18.9	0.020	10.5
Mauna Loa	1-8	12.0		0.018	8.1
	8-15	6.17		0.018	4.2
	15-22	8.86		0.020	6.0
	22-5/1	6.23	8.32	0.023	4.2
San Juan	1-8	6.59		0.019	4.4
	8-15	6.83		0.018	4.6
	15-22	22.5		0.020	15.2
	22-5/1	7.91	8.77	0.023	5.4
Miraflores	1-8	23.3		0.018	15.8
	8-15	3.08		0.018	2.0
	15-22	2.52		0.021	1.7
	22-5/1	4.00	8.21	0.022	2.7
Guayaquil	1-8	0.886		0.020	0.60
	8-15	0.817		0.019	0.55
	15-22	0.316		0.028	0.21
	22-5/1	0.253	0.568	0.024	0.17
Lima	1-8	0.287		0.033	0.19
	8-15	0.187		0.029	0.12
	15-22	0.200		0.030	0.14
	22-5/1	0.157	0.234	0.021	0.11
Chacaltaya	1-8	0.0551		0.081	0.04
	8-15	0.120	0.0876	0.030	0.06
Antofagasta	1-8	0.226		0.030	0.15
	8-15	0.184		0.029	0.12
	15-22	0.120		0.038	0.08
	22-5/1	0.164	0.174	0.025	0.11
Santiago	1-8	0.156		0.034	0.10
	8-15	0.176		0.041	0.12
	15-22	0.116		0.035	0.08
	22-5/1	0.262	0.176	0.021	0.18
Puerto Montt	1-8	0.140		0.039	0.10
	8-15	0.665		0.081	0.04
	15-22	0.813		0.036	0.46
	22-5/1	0.152	0.110	0.037	0.10
Punta Arenas	1-8	0.0481		0.089	0.32
	8-15	0.205		0.034	0.14
	15-22	0.0511		0.081	0.03
	22-5/1	0.0748	0.0948	0.070	0.05

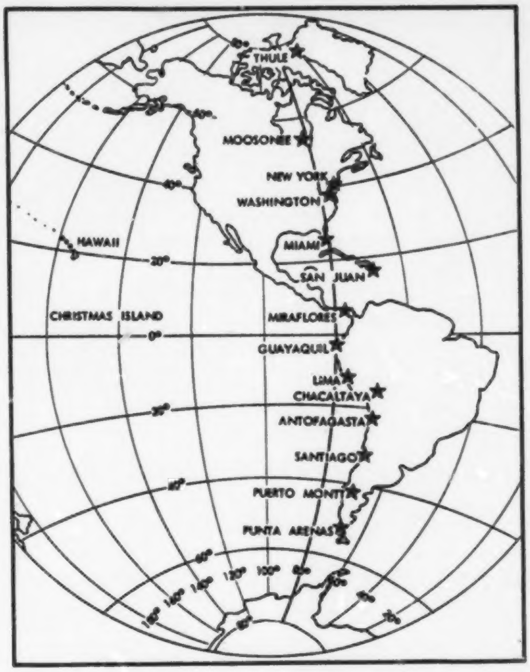
THULE
MOOSONEE
NEW YORK
WASHINGTON
HAWAII
MIAMI
SAN JUAN
CHRISTMAS ISLAND
MIRAFLORES
GUAYAQUIL
LIMA
CHACALTAYA
ANTOFAGASTA
SANTIAGO
PUERTO MONTT
PUNTA ARENAS
20°
0°
20°
40°
60°
120°
100°
80°

Figure 1.—ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDAIN (WEST)

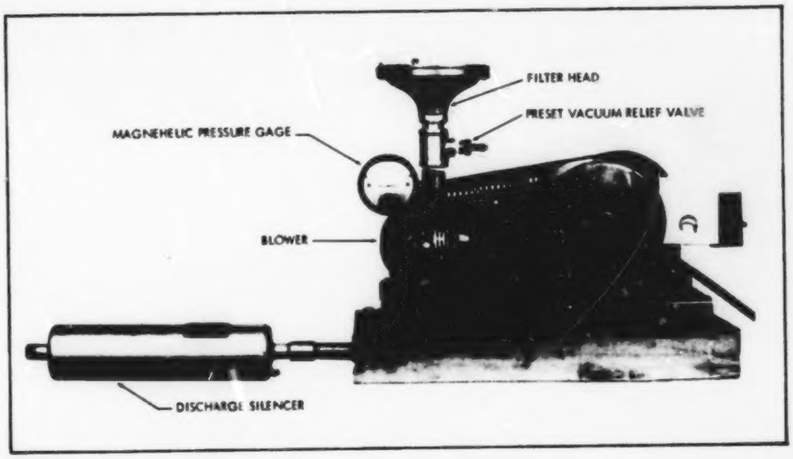
FILTER HEAD
PRESET VACUUM RELIEF VALVE
MAGNEHELIC PRESSURE GAGE
BLOWER
DISCHARGE SILENCER

Figure 2.—NEW AIR SAMPLING EQUIPMENT FOR THE 80TH MERIDIAN NETWORK

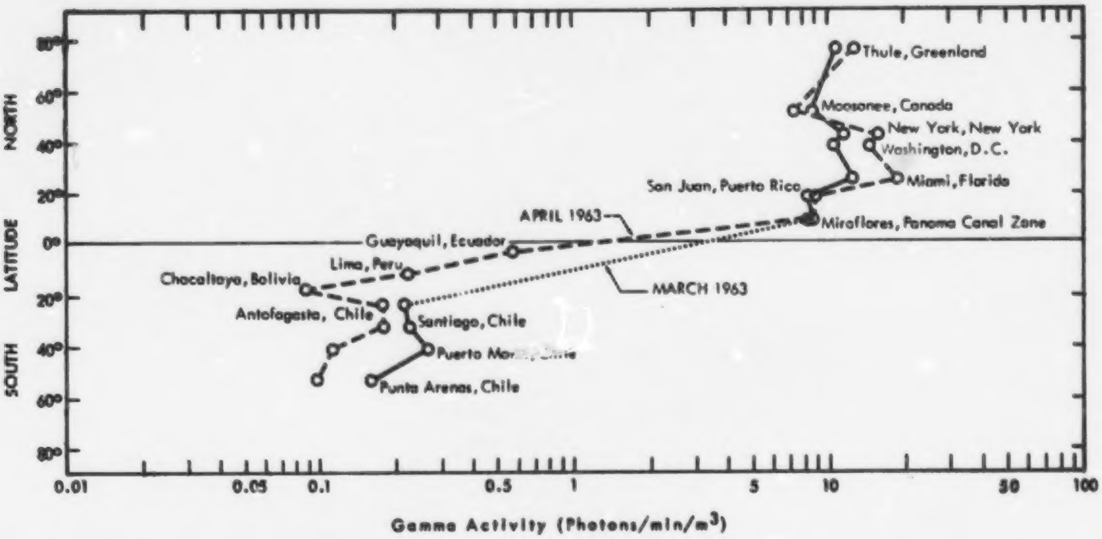

FIGURE 3.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, MARCH AND APRIL 1963

centrations of antimony-124 (Sb^{124}) existed along the 80th meridian during March and April. This non-fission product contribution is not expected to affect the validity of the total gamma activity estimates, since the photon efficiency of the HASL counter for Sb^{124} has been found to agree with the average fission product photon efficiency adopted in the January report (0.35 gamma counts per photon). The total beta activity approximations are tentative, however, since large quantities of Sb^{124} distort the dating ratio and since the beta-to-gamma ratio for this nuclide is lower than that for mixed products.

REFERENCE

(1) Collins, W. R., Jr.: Fission Product Gamma Activity in Airborne Particulates, The 80th Meridian Network, January 1963, *Radiological Health Data*, 4:342–6, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (July 1963).

SECTION II.—FOOD

Radionuclides in Institutional Diet Samples

January–March 1963

Division of Radiological Health, Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is being administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 21 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from financially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (sampling point), except one, is located in a community from which the PHS Pasteurized Milk Network collects samples. The analytical data from this program supplement the findings for the Institutional Diet Sampling Program.

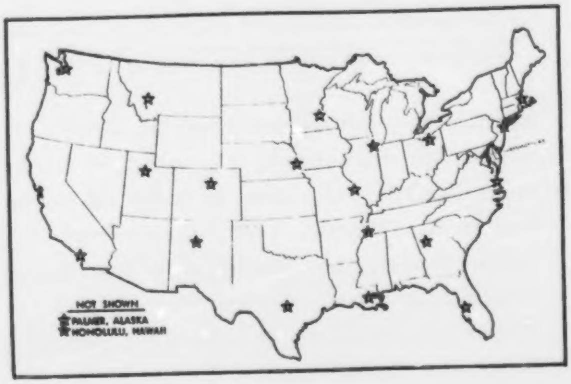

FIGURE 1.—INSTITUTIONAL DIET SAMPLING LOCATIONS, MARCH 1963

Sampling Procedure

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Each day's sample is kept

TABLE 1.—INSTITUTIONAL DAILY DIETARY

Station	Month (1963)	Alaska, Palmer	California, Los Angeles	Colorado, Denver	Florida, Tampa	Georgia, Atlanta	Hawaii, Honolulu	Louisiana, New Orleans	Massachusetts, Boston	Minnesota, Minneapolis	Missouri, St. Louis	Montana, Helena
Age (years)		6–18	6–18	6–18	1–15	6–18	5–16	4–19	—	[a] <1–16	4–16	4–16
Total weight (kg/day)	Jan.	2.33	1.48	1.31	1.89	1.73	1.71	2.03	1.81	1.60		1.93
	Feb.	1.55	1.07	1.80	1.88	1.38	2.07	2.00	1.54	1.54		1.67
	Mar.	1.90	1.42	2.13	0.88	1.54	1.94	2.38	1.97	1.56	2.93	1.68
Calcium (g/day)	Jan.	1.7	0.7	0.6	1.2	0.9	0.5	1.4	1.2	0.6		0.8
	Feb.	0.7	0.5	1.4	1.0	0.9	0.9	1.5	1.3	0.6		1.1
	Mar.	1.3	0.7	1.4	0.6	0.8	0.2	1.6	1.6	0.7	2.2	1.3
Phosphorus as phosphate (g/day)	Jan.	5.4	3.2	2.6	4.3	4.0	2.6	4.7	5.8	2.6		3.1
	Feb.	3.6	1.9	3.2	3.7	3.2	3.9	4.9	4.1	2.6		4.0
	Mar.	4.5	3.1	4.9	0.7	1.1	3.3	2.1	3.8	3.0	7.3	4.2
Potassium (g/day)	Jan.	4.2	2.5	1.8	2.5	2.0	1.9	3.2	3.2	2.4		3.3
	Feb.	3.3		3.2	2.0	1.6	3.1	3.1	2.5	2.6		2.8
	Mar.	3.4	2.1	6.2	1.2	1.5	2.5	3.3	3.3	2.7	5.3	3.1
Total radium (pc/day)	Jan.	2.0	2.0	1.0	4.0	<2.0	8.0	6.3	<1.0	3.0		3.0
	Feb.	3.0	<1.0	<1.0	<2.0	<2.0	10.0	2.5	<1.0	<1.0		2.0
	Mar.	<1.0	1.0	1.0	2.9	5.2	2.0	4.7	<1.0	1.0	2.0	3.0
Strontium-89 (pc/day)	Jan.	30	<5	10	40	45	30	140	<5	5		5
	Feb.	30	<5	10	30	50	60	290	<5	15		25
	Mar.	60	8	45	30	60	65	350	<5	<5	20	30
Strontium-90 (pc/day)	Jan.	37	5	10	11	17	6	30	25	9		15
	Feb.	16	2	24	12	17	8	22	22	9		13
	Mar.	17	3	17	11	16	8	70	54	12	30	21
Cesium-137 (pc/day)	Jan.	255	35	90	125	50	35	110	170	80		85
	Feb.	155		110	90	55	85	140	125	85		100
	Mar.	145	35	155	70	60	155	210	180	105	115	80
Barium-140 (pc/day)	Jan.	<10	<10	<10	<20	<20	<10	<25	30	<10		<10
	Feb.	<10		<10	<15	<15	<10	<25	10	<10		<10
	Mar.	<10	<10	<10	<10	<20	<10	<30	<10	<10	<10	<10
Iodine-131 (pc/day)	Jan.	70	40	<10	<20	<20	<10	20	30	<10		<10
	Feb.	<10		<10	<15	<15	<10	30	<10	<10		<10
	Mar.	<10	20	<10	<10	<20	<10	<30	<10	40	<10	<10

[a] Food samples not collected from children too young for solid diet.
[b] Food samples collected from 5–14 year age group.

frozen during the collection period. After compositing the total sample, it is packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

Each sample was packaged in three containers: one containing solid food minus seeds, pits, rinds, shells and bones that would not ordinarily be eaten; one containing dairy products such as milk, cottage cheese, and ice cream; and one containing soft drinks, coffee, tea, and water. A record of the contents of each meal and the approximate weight of each item was made by the institution's dietician and sent with the sample. Samples usually range from 6 to 16 liters in volume and weigh from 8 to 20 kilograms.

Analytical Procedures

Because calcium and phosphorus compounds may have an effect on the uptake of important boneseeking radionuclides such as strontium-89 and strontium-90 (*2*), they are included in the analytical program. Total weight, stable calcium, and stable potassium determinations are obtained by conventional, gravimetric or spectrophotometric methods. Phosphate determinations are made by a colorimetric technique.

The radioanalysis program is designed around three basic procedures: (1) gamma spectroscopy (2) chemical separation of strontium-89 and strontium-90 with subsequent counting, and (3) total radium analysis. In the absence of interferences other than that from naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for the gamma scan on a per-kilogram basis are: iodine-131, 10 pc/kg; cesium-137, 5

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INTAKE (BASED ON A 7-DAY COMPOSITE SAMPLE)

Station	Month (1963)	Nebraska, Omaha	New Mexico, Albuquerque	New York, New York	Ohio, Cleveland	Tennessee, Memphis	Texas, Austin	Utah, Salt Lake City	Virginia, Norfolk	Washington, Seattle	Monthly Minimum Average	Monthly Maximum Average
Age (years)		6–18	[b] <1–14	8–15	6–15	8–18	6–18	12–18	10–18	6–16	—	—
Total Weight (kg/day)	Jan.	1.77	1.86	1.66	1.89	1.09	2.20	1.36	1.06	2.85	1.77	1.77
	Feb.				1.92	1.37	2.25	1.72	1.34	3.03	1.72	1.72
	Mar.	1.70	1.80		1.92	1.33	2.35	1.56	1.05	2.71	1.82	1.82
Calcium (g/day)	Jan.	1.3	1.4	1.9	1.4	0.5	1.4	0.6	0.6	2.1	1.1	1.1
	Feb.				2.0	1.2	1.4	1.3	0.6	2.2	1.2	1.2
	Mar.	1.2	1.6		1.4	1.0	1.2	1.1	0.5	2.2	1.2	1.2
Phosphorus as phosphate (g/day)	Jan.	4.3	4.7	4.6	7.1	1.9	5.6	2.7	2.6	7.4	4.1	4.1
	Feb.				5.7	3.9	5.7	4.7	3.2	7.5	4.1	4.1
	Mar.	3.9	5.2		3.9	1.1	1.9	3.7	0.9	7.9	3.5	3.5
Potassium (g/day)	Jan.	3.6	3.8	3.3	4.0	2.1	3.6	2.6	1.6	4.8	3.0	3.0
	Feb.				3.0	2.5	3.1	3.1	2.2	3.6	2.8	2.8
	Mar.	2.9	2.5		3.4	2.3	2.9	2.8	1.4	3.1	2.9	2.9
Total radium (pc/day)	Jan.	1.0	1.0	<1.0	<1.0	<2.0	<3.0	2.0	<2.0	6.0	2.2	2.8
	Feb.				<1.0	<2.0	<3.0	1.0	<2.0	12.0	1.8	2.8
	Mar.	<1.0	1.0		<1.0	2.3	3.7	<1.0	1.0	1.0	1.8	2.1
Strontium-89 (pc/day)	Jan.	20	20	<5	<5	45	120	5	20	80	34	35
	Feb.				<5	50	70	5	70	60	46	47
	Mar.	35	25		<5	85	85	40	40	115	58	58
Strontium-90 (pc/day)	Jan.	21	9	25	18	7	20	9	13	25	16	16
	Feb.				25	17	23	15	12	36	18	18
	Mar.	7	5		39	17	22	8	12	29	20	20
Cesium-137 (pc/day)	Jan.	105	<5	85	130	45	110	75	35	200	96	97
	Feb.				105	55	55	170	45	230	106	106
	Mar.	70	35		80	65	70	125	35	190	104	104
Barium-140 (pc/day)	Jan.	70	<10	<10	<10	<15	<25	<10	<15	<10	6	18
	Feb.				20	<15	<25	<10	<15	150	11	23
	Mar.	<10	<10		<10	<20	<30	80	<10	<10	4	17
Iodine-131 (pc/day)	Jan.	<10	<10	<10	30	<15	<25	<10	<15	60	14	23
	Feb.				<10	<15	<25	<10	<15	<10	2	14
	Mar.	<10	<10		<10	<20	<30	<10	<10	<10	3	15

pc/kg; and barium-140, 10 pc/kg. Approximate minimum detectable concentrations for strontium-89, strontium-90, and total radium are: 5, 1, and 1 pc/kg, respectively.

Total radium is determined by ashing, separation, and coprecipitation of radium as sulfate or chromate. After samples are transferred to planchets and dried, alpha activity is measured by an internal proportional counter with an appropriate delay for checking ingrowth of radium daughters. Since naturally-occurring radionuclides may contribute to the reported total radium values, the total radium technique is a practical screening indicator only. The bone dose, calculated by assuming total radium to be only radium-226, would therefore be moderately high.

Data

Table 1 presents the dietary intake data expressed on a per-day basis from January 1963 through March 1963 for the 20 institutions from which samples were received. Also contained in the table is the range of ages of children at each institution. The reported iodine-131 values are based on the iodine-131 content of the sample at the end of the sample collection period. Therefore, the true iodine-131 intakes may be somewhat greater than the reported values.

Certain of the radioanalyses are reported by the laboratories as being "less than" (<) a specified value. For data averaging, the method employed for presentation in table 1 is that all "less-than" data are assumed to be equal to the full "less-than" values as they appear in the column entitled "monthly maximum averages." The column entitled "monthly minimum averages" reflects the averages in which all "less than" values are considered to be zero.

Strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 averages of the daily intakes at the institutions, as well as announced atmospheric nuclear detonations for 1961 through 1963, are shown in figure 2.

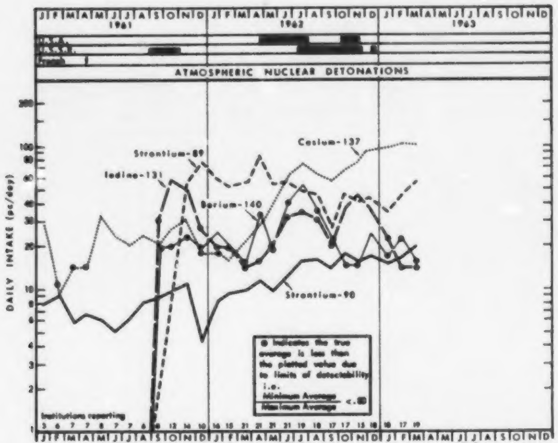

FIGURE 2.—RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES—AVERAGE OF INSTITUTIONS

For convenience the data are presented graphically in figures 3–10 as station distributions versus daily intake. These are not graphs of continuous functions as might be inferred from their appearance. For example, in figure 3, total dietary intake of food is divided into six ranges (<1.00, 1.00–1.49, 1.50–1.99, 2.00–2.49, 2.50–2.99, and 3.00–3.50 kg/day), and the number of institutions in each range is noted and plotted as a bar graph. The maximum of each bar is connected by a smooth curve. This type of construction is used for each month for each item represented in figures 3–10. The number of stations used in constructing these graphs was 18, 17, and 19 for the months of January, February and March 1963, respectively. A variation of two institutions is probably not significant in considering trends in the data.

Discussion of Data

During the 3-month period reported, the dietary intake of strontium–90 ranged between 2 and 70 pc/day, with 35 of 54 institution-months* being, for purposes of comparison, in the lowest Federal Radiation Council (FRC) Range of intake. This lowest Range established for strontium–90 by the FRC is 0 to 20 pc/day averaged over the period of one year (*3*, *4*).

The strontium–89 distribution (figure 8) shows that the majority of institution-month values are below 40 pc/day. The FRC Range I for strontium–89 is 0 to 200 pc/day (*3*). Only the New Orleans station samples had values in FRC Range II, which is 200 to 2,000 pc/day.

The dietary intake of total radium ranged between <1.0 and 12.0 pc/day with 94 percent of the institution-months being 6.0 pc/day or less. Assuming the radium–226 component to be one-third of the total radium activity (*3*), the intake of radium–226 via the diet probably approaches the top of FRC Range I (0 to 2 pc/day for radium–226) at a few institutions.

Following the resumption of nuclear weapons testing in the atmosphere in 1961, iodine–131 dietary intake increased from nondetectable levels to an institutional high of 390 pc/day. During the period of January–March 1963, the institutional high was 70 pc/day. FRC Range II for iodine–131 is 10–100 pc/day (*3*). Barium–140 was generally not detectable during this period, although the maximum intake of 150 pc/day was observed at Seattle in February.

The cesium–137 dietary intake ranged from <5 to 255 pc/day during the period reported, with 28 of 53 reported values being less than 100 pc/day.

The distributions of total intake of food by weight for this quarter (figure 3) are similar to those for the previous period. The total weight of food consumed ranged between 0.88 and 3.03 kg/day, with 40 of 54 institution months being between 1 and 2 kg/day.

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* An institution-month is one datum value per institution per month. (e.g., 20 institutions reporting one value per month for 3 months is 60 institution-months).

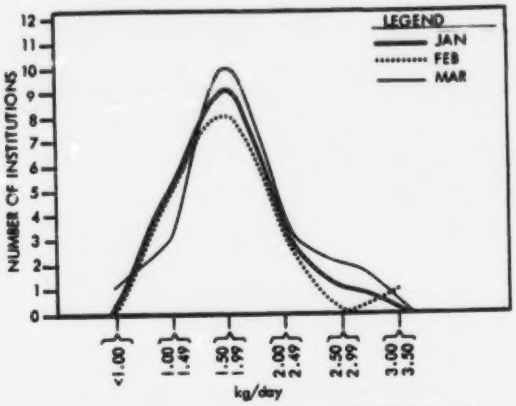

FIGURE 3.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS TOTAL DAILY DIETARY INTAKE ON A WEIGHT BASIS

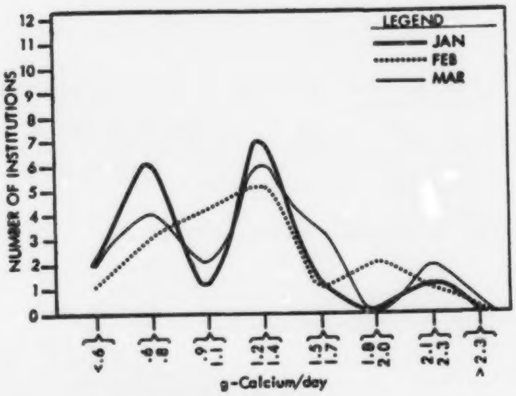

FIGURE 4.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY CALCIUM INTAKE

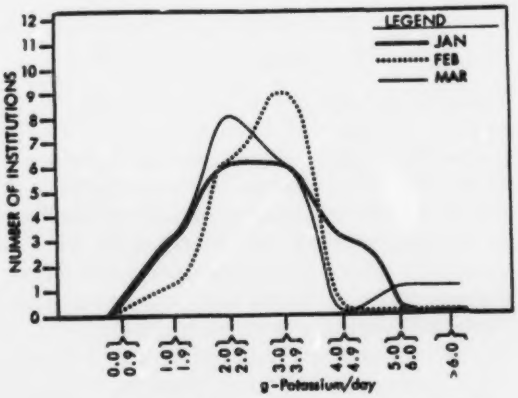

FIGURE 5 -- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY POTASSIUM INTAKE

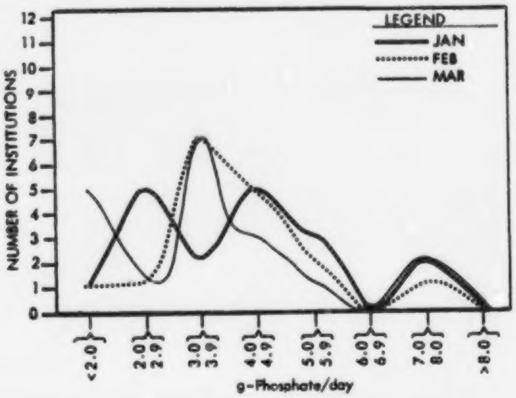

FIGURE 6.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY PHOSPHATE INTAKE

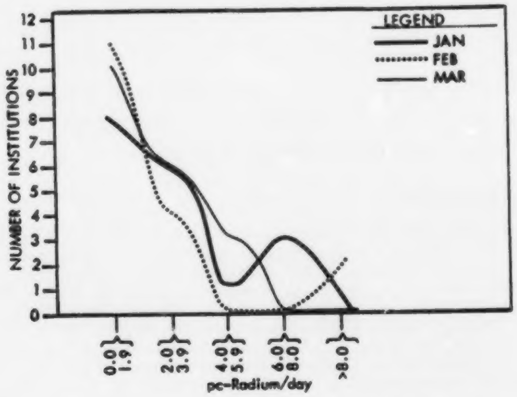

FIGURE 7.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY TOTAL RADIUM INTAKE

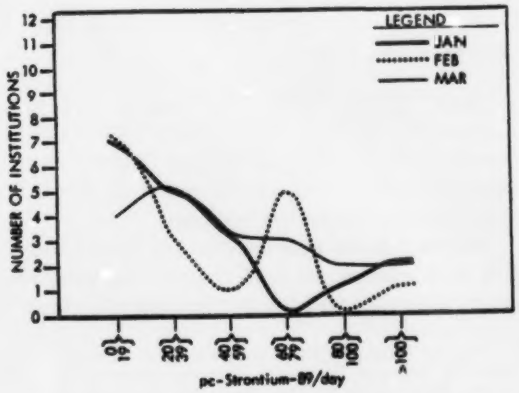

FIGURE 8.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY STRONTIUM-89 INTAKE

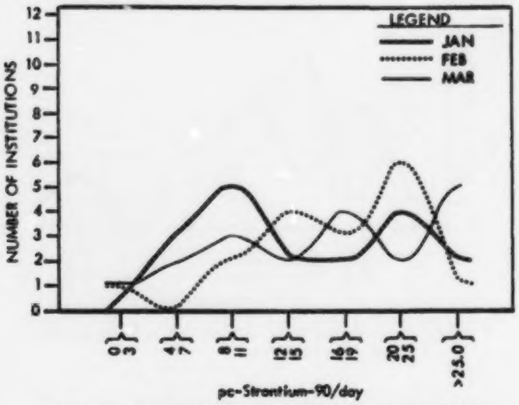

FIGURE 9.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY STRONTIUM-90 INTAKE

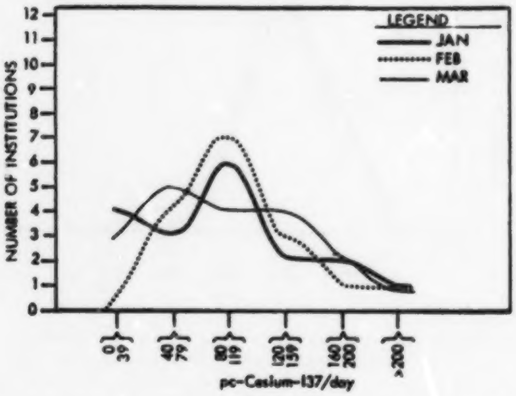

FIGURE 10.—DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY CESIUM-137 INTAKE

The calcium intake ranged between 0.2 and 2.2 g/day while 67 percent of the institution-month values were greater than 0.8 g/day.

REFERENCES

(*1*) Anderson, E. C., and D. J. Nelson, Jr.: Surveillance for Radiological Contamination in Foods, *American Journal of Public Health*, *52*:1391–400 (September 1962).
(*2*) Chen, P. S., Jr., A. R. Terepka, and H. C. Hodge: The Pharmacology and Toxicology of the Bone Seekers, *Annual Review of Pharmacology 1*:369–96 (1961).
(*3*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (September 1961), price 20 cents.
(*4*) Chadwick, Donald R. and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data*, *3*:159–65 (May 1962).

Previous coverage in *Radiological Health Data:*

Period	Issue
January–August 1961	*February 1962*
January 1961–February 1962	*July 1962*
March–June 1962	*December 1962*
July–September 1962	*April 1963*
October–December 1963	*July 1963*

Tri-City Diet Study[1]

November 1962–January 1963

Joseph Rivera[2]

Since March 1960, the Health and Safety Laboratory through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium-90. Using data from the U.S. Department of Agriculture, "Household Food Survey of 1955," the annual consumption by an average individual can be grouped into the same 19 food categories. The annual dietary intake of strontium-90 can be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data from the "Household Food Survey of 1955" are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is deboned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the wasted food.

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[1] *Fallout Program Quarterly Summary Report, HASL-138*, 163–165, Office of Technical Services, Department of Commerce, Washington 25, D.C. (July 1963), price $3.50.

[2] Mr. Rivera is a physicist on the staff of the Environmental Studies Division, Health and Safety Laboratory, U.S. Atomic Energy Commission.

After two samplings at each city it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. The specific numbers used to calculate calcium intake are given in HASL–113 (*1*).

Results obtained from the eleventh sampling of foods (November 1962–January 1963) are presented in table 1. The variation with time of the daily intake of strontium–90 in the three cities is plotted in figure 1.

Discussion

The trend of increasing daily intake of strontium–90 at each of the three cities, which started after the resumption of atmospheric testing of nuclear weapons by the U.S.S.R. in September 1961, is seen in figure 1 to have continued through the winter of 1962. The average daily strontium–90 intake during 1960, 1961, and 1962 at each of the cities is shown in table 2. Of the three cities, New York City has always had the highest levels and San Francisco the lowest. The average daily intake of strontium–90 at New York City in 1962 was about 4.0 pc/day greater than that in 1961. If a similar increase occurred in 1963, the average daily intake of strontium–90 in 1963 at New York City would be about 19 pc/day, which is near the top of Range I (0–20 pc/day) of the intake guidance established by the Federal Radiation Council (*2*).

Partly due to its high annual consumption, milk continues to be the predominant source of strontium–90 in the diet.

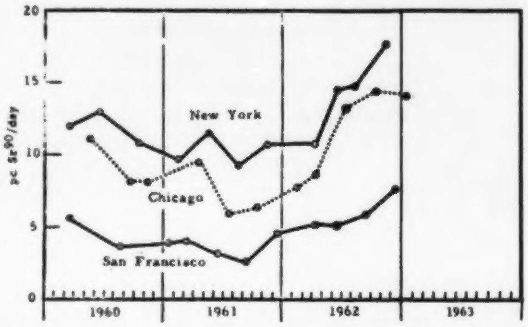

FIGURE 1.—DAILY INTAKE OF STRONTIUM–90 IN TRI-CITY TOTAL DIETS

TABLE 1.—AVERAGE PER PERSON DIETARY CONSUMPTION AND STRONTIUM–90 INTAKE—ELEVENTH SAMPLING

Food Category	Average U. S. consumption		New York City November 1962		Chicago January 1963		San Francisco December 1962	
	Diet kg/yr	Calcium (g/yr)	pc/kg	pc/yr	pc/kg	pc/yr	pc/kg	pc/yr
Bakery products	37	37.0	[a]18.7 ± 1.4	692	[a]16.8 ± 1.2	622	[a]9.7 ± 0.8	359
Whole grain products	11	10.0	35.8 ± 1.6	394	41.5 ± 1.8	457	21.5 ± 1.1	237
Eggs	16	9.1	1.2 ± 0.1	19	3.2 ± 0.1	51	1.7 ± 0.1	27
Fresh vegetables	43	15.0	16.8 ± 0.6	722	7.4 ± 0.4	318	3.8 ± 0.4	163
Root vegetables	17	6.1	15.7 ± 0.6	267	6.5 ± 0.3	111	5.5 ± 0.3	94
Milk	221	234.3	10.0 ± 0.5	2210	9.5 ± 0.5	2100	5.0 ± 0.4	1105
Poultry	17	9.2	1.2 ± 0.1	20	1.1 ± 0.1	19	1.1 ± 0.1	19
Fresh fish	8	10.8	0.5 ± 0.1	4	0.9 ± 0.1	7	0.3 ± 0.1	2
Flour	43	8.6	17.2 ± 0.4	740	12.7 ± 0.4	546	4.2 ± 0.3	181
Macaroni	3	0.7	9.3 ± 0.4	28	14.5 ± 0.6	44	8.3 ± 0.4	25
Rice	3	1.1	1.9 ± 0.3	6	2.4 ± 0.3	7	1.9 ± 0.2	6
Meat	73	10.9	2.3 ± 0.2	168	1.0 ± 0.1	73	0.8 ± 0.1	58
Shellfish	1	0.8	5.0 ± 0.5	5	0.7 ± 0.1	1	1.3 ± 0.1	1
Dried beans	3	2.9	12.0 ± 1.3	36	17.3 ± 1.5	52	11.0 ± 1.6	33
Fresh fruit	68	13.6	9.1 ± 0.4	619	2.0 ± 0.2	136	1.9 ± 0.3	129
Potatoes	45	5.8	3.0 ± 0.4	135	9.1 ± 0.5	410	1.5 ± 0.4	68
Canned fruit	26	1.3	1.8 ± 0.2	47	1.7 ± 0.2	44	0.7 ± 0.1	18
Fruit juices	19	1.7	3.2 ± 0.3	61	2.9 ± 0.3	55	2.2 ± 0.3	42
Canned vegetables	20	4.2	10.2 ± 0.8	204	5.7 ± 0.5	114	1.2 ± 0.4	24
Annual intake	674	383		6377		5167		2591
pc Sr^{90}/g Ca in total diet				16.7	-------------	18.5	-------------	6.8

[a] Error terms are one standard deviation (due to counting).

TABLE 2.—ANNUAL AVERAGE DAILY STRONTIUM-90 INTAKE, 1960–1962

[pc/day]

Date	New York City	Chicago	San Francisco
1960	12.0	9.2	4.3
1961	10.2	7.4	3.5
1962	14.4	12.6	5.8

REFERENCES

(1) U.S. Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL-113*, Office of Technical Services, Department of Commerce, Washington 25, D.C. (July 1, 1961), price $2.50.

(2) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (September 1961), price 20¢.

Recent coverage in *Radiological Health Data:*

Period	*Issue*
Sixth sampling (August–October 1961)	*June 1963*
Seventh sampling (November 1961–February 1962	*September 1962*
Eighth sampling (April 1962)	*January 1963*
Ninth sampling (June–July 1962)	*March 1963*
Tenth sampling (August–September 1962)	*June 1963*

Temporal and Geographical Distributions of Strontium-90 and Cesium-137 in Food

1960–1962

Edwin P. Laug [1]

Since 1960, the Food and Drug Administration (FDA) has been collecting and analyzing individual foods in order to determine their content of strontium-90 and cesium-137 resulting from fallout. This report summarizes and interprets all data amassed during the surveillance period of 1960, 1961, and 1962. No 1963 data are included. Except where noted, all products were raw and unprocessed. About 3200 individual samples were analyzed for strontium-90 content and 400 samples were analyzed for cesium-137. The sampling base for this survey was quite broad, including 92 different varieties of domestic and imported foods. Included in this summary are results from a survey of 24 varieties of baby food. Experiments were conducted concurrently to determine the effect of processing operations, such as peeling, washing, canning, freezing, and milling on the amount and distribution of fallout contamination.

Sampling Methodology

Individual foods were sampled on as broad a basis as possible with respect to variety. Because of different growing times and areas, however, a regular schedule or fixed geographical grid could not be systematized, as is the case with the milk, water and air radioactivity monitoring networks operated by the Public Health Service. Samples were drawn at harvest from all major growing areas in the continental U.S. (see figure 1) and repeated samplings were made throughout the period covered by this resume. Products sampled, sampling frequency, and priorities assigned were reviewed at intervals as surveillance findings became available. Occasionally, decisions to modify existing schedules were made when the air sampling network of the Public Health Service indicated localized fallout situations. Most foods collected were raw agricultural products, which were usually unwashed and unpeeled, and generally in the condition in which they would be found in a warehouse or store. Most imports (tea bales, spice bales, coffee beans, cocoa beans) were also raw and unprocessed. When processed samples were collected, an attempt was made to identify the raw lot from which the finished product was manufactured.

All samples were collected by FDA inspectors, either directly from the individual grower or from the storage sheds where crops were assembled before shipment. Import samples were usually collected at dockside. Collection records kept by the inspector included date of collection, date of harvest, date of planting, name of grower or growers, location of farm by county and State or foreign country, and name and location of marketing cooperative or dealer. Manufactured items

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[1] Dr. Laug is Chief, Radioactivity Branch, Division of Pharmacology, Food and Drug Administration, Department of Health, Education, and Welfare, Washington 25, D.C.

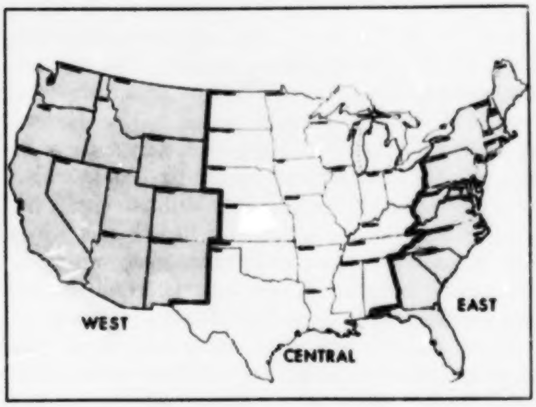

FIGURE 1.—HARVEST REGIONS

such as baby foods or flour were identified by dealer and/or manufacturer and also by source of the raw material.

Radiochemical Methodology

Analyses for strontium-90 were essentially as outlined in the HASL Manual of Standard Procedures (*1*). Samples were prepared and analyzed for cesium-137 as described in an earlier report (*2*).

RESULTS

Strontium-90 Content of Individual Foods and Food Groups

Table 1 gives the content of strontium-90 by food groups arranged in descending order of concentration. Individual foods which make up the groups are listed in tables 2 through 12. Tea and spices appear to carry the highest levels of contamination in human food, while sea foods, eggs and white potatoes seem to contribute the least strontium-90 to the food chain. Baby foods generally reflect the strontium-90 levels found in the corresponding foods eaten by adults. Considering the association of strontium with calcium, the high levels in bone are not surprising. Poultry bones, however, contain less strontium-90 than other bones—a fact that may be explained by the relatively large accretion of strontium-90 in egg shells. Worthy of comment are Brazil nuts, which contain about five times as much strontium-90 as the other nuts. It is known that Brazil nuts translocate radium from the soil (*3*), and as strontium belongs to the same periodic grouping of elements (Group II), we may assume that the

TABLE 1.—STRONTIUM-90 CONTENT OF HUMAN FOODS PRODUCED AND HARVESTED IN 1960–1962

Type of food	No. of varieties	No. of samples	Picocuries strontium-90 per kilogram	
			Average	Range
Raw agricultural products				
Tea[1]	1	159	390	19–1,720
Spices	10	61	165	1.9–2,590
Brazil nuts	1	9	63	18–119
Dairy products[2]	2	84	43	2.1–140
Leafy vegetables[3]	6	335	30	0.5–299
Grains[4]	4	279	29	0.5–447
Legumes[5]	4	234	16	0.0–272
Berries[6]	4	86	16	0.9–110
Coffee[1]	1	130	16	0.9–48
Cocoa beans	1	33	14	1.3–25
Brassicae[7]	4	180	12	0.2–100
Nuts[8]	5	78	12	0.0–81
Root vegetables[9]	6	293	11	0.1–118
Miscellaneous vegetables[10]	2	34	6.2	0.2–38
Fruits[11]	20	485	4.0	0.0–46
Rice	1	11	3.7	0.2–8.3
White potatoes	1	134	2.4	0.0–12
Egg substance[12]	1	27	1.8	0.3–3.8
Corn	1	55	1.5	0.0–8.8
Sea food[13]	10	222	0.9	0.0–9.8
Processed baby foods				
Cereal products	6	40	11	0.1–49
Strained vegetables	7	33	7.0	0.8–25
Strained fruits	6	29	0.9	0.0–3.9
Strained meats	5	13	0.9	0.1–2.7
Organic calcium sources				
Fresh bone[14]	4	4	595	431–873
Bone flour	—	13	550	75–2,100
Egg shells	1	21	407	39–1,300
Fresh poultry bone[15]	2	12	81	11–190

[1] Leaves or beans respectively, not the beverage.
[2] Cheese and evaporated milk.
[3] Lettuce, spinach, parsley, collards, kale, celery.
[4] Wheat, oats, barley, rye.
[5] Lima beans, snap beans, soybeans, peas.
[6] Strawberries, blueberries, blackberries, cranberries.
[7] Cabbage, Brussels sprouts, cauliflower, broccoli.
[8] Pecans, cashews, walnuts, almonds, peanuts.
[9] Carrots, beets, turnips, radishes, onions, sweet potatoes.
[10] Artichokes, asparagus.
[11] With exception of berries.
[12] Without shell.
[13] Shellfish, crustacea, oceanic fish.
[14] Beef, pork, veal, poultry waste discards from FDA Teen-Ager Diet Study, 1961–1962, Washington, D.C.
[15] Chicken and turkey.

TABLE 2.—STRONTIUM-90 CONTENT OF VEGETABLES HARVESTED IN 1960–1962

Variety	No. of samples	Picocuries of strontium-90 per kilogram	
		Average	Range
Leafy			
Kale	3	182	22 –287
Collards	14	123	29 –299
Parsley	28	86	21 –178
Spinach	60	41	2.7–264
Lettuce	125	16	0.5–178
Celery	105	11	0.7– 60
Legumes			
Soybeans	32	42	10 –272
Snap beans	102	18	0.3– 98
Peas	62	8.0	0.0– 53
Lima beans	38	5.6	0.4– 28
Brassicae			
Broccoli	17	23	0.2–100
Cabbage	133	12	0.3– 68
Brussels sprouts	7	4.9	0.2– 8.1
Cauliflower	23	3.7	0.6– 10
Miscellaneous			
Artichoke	8	17	3.9– 38
Asparagus	26	2.5	0.2– 12

plant displays a similar propensity to concentrate this nuclide. Grains such as wheat, oats, rye and barley rank relatively high in the order of strontium-90 content, while rice and corn rank at the lower end of the order. In the case of corn, it appears obvious that the husk effects nearly complete protection from surface contamination. A striking difference between sweet potatoes and white potatoes is evident; the former contains about ten times as much strontium-90 (table 3). Among the fruits (table 4) the berries are seen to carry significantly higher levels of strontium-90 than some of the smooth skinned fruits such as apples and tomatoes. The latter, in fact, contain some of the lowest levels of strontium-90 observed in this survey.

Because of the universality of fallout contamination in food, an orientation as to the significance of findings listed in table 1 is very desirable. The Federal Radiation Council has established a set of intake guidance ranges for strontium-90 which apply for normal peacetime operations involving the controlled use of atomic energy. These ranges are based on the concentration of strontium-90 in food and on the amount eaten. The Federal Radiation Council has suggested that a daily intake of 200 picocuries of strontium-90 averaged over a year might be a desirable upper limit, but it has stated that any possible health risk which may be associated with exposures even substantially above the guide levels has not resulted in a detectable increase in the incidence of disease (*4*).

Based on the estimated daily weight of food eaten and the average strontium-90 concentration, calculated intakes of strontium-90 have been listed in table 12 in descending order. It can be seen that, of 5 major food groups surveyed, dairy products head the order. Tea and spices, which have a relatively high content of strontium-90, rank well down in the order, and contribute less than 1 pc per day, on the average, to the diet.

In order to estimate the potential strontium-90 intake under the worst situation, calculations of intake were also derived from the highest strontium-90 concentration recorded for any particular food item. Based on values in table 12, the potential daily intake from ingestion of a number of food groups is as follows: grain products, 100 pc; dairy products, 59 pc; root vegetables, 42 pc; vegetables, 55 pc; fruits, 37 pc. For individual foods: lettuce, 5.9 pc; snap beans, 2.3 pc; onions, 2.1 pc. Thus, it is seen that only in exceptional cases occurring at

TABLE 3.—STRONTIUM-90 CONTENT OF ROOT VEGETABLES HARVESTED IN 1960-1962

Variety	No. of samples	Picocuries of strontium-90 per kilogram	
		Average	Range
Sweet potatoes	32	22	2.9-118
Turnips	29	16	0.5- 65
Beets	48	15	0.7-104
Radishes	29	9.8	0.6- 92
Onions	80	7.5	0.1- 76
Carrots	75	4.9	0.5- 25
Potatoes	134	2.4	0.0- 12

TABLE 4.—STRONTIUM-90 CONTENT OF FRUITS HARVESTED IN 1960-1962

Variety	No. of samples	Picocuries of strontium-90 per kilogram	
		Average	Range
Cranberries	10	34	3.4-110
Strawberries	80	15	0.9- 59
Blueberries	12	12	5.7- 23
Blackberries	4	12	2.7- 22
Oranges	9	11	1.5- 27
Grapefruit	7	5.1	0.4- 16
Squash	47	7.7	0.4- 12
Pumpkin	24	6.1	0.5- 26
Cucumber	24	5.3	0.5- 17
Cantaloupe	8	3.8	0.1- 24
Olives	7	13	2.3- 46
Figs	17	7.5	2.1- 9.5
Cherries	48	6.1	0.9- 16
Grapes	15	5.4	0.4- 15
Raisins	8	3.5	0.0- 8.8
Peaches	68	3.3	0.4- 12
Pears	9	2.6	0.1- 14
Dates	7	2.3	0.6- 8.7
Avocado	6	1.5	0.1- 4.7
Apples	58	1.1	0.1- 7.0
Bananas	7	0.2	0.1- 0.5
Egg Plants	2	5.4	4.3- 6.5
Peppers	27	2.6	0.0- 11
Tomatoes	104	1.9	0.1- 11

TABLE 5.—STRONTIUM-90 CONTENT OF GRAINS HARVESTED IN 1959-1962

Variety	No. of samples	Picocuries of strontium-90 per kilogram	
		Average	Range
Oats	43	43	2.0-447
Rye	26	40	6.5-255
Wheat	168	25	0.9-241
Barley	42	21	0.5- 90
Rice	11	3.7	0.2- 8.3
Corn	55	1.5	0.0- 8.8

TABLE 6.—STRONTIUM-90 CONTENT OF COFFEE, TEA, AND COCOA BEANS IMPORTED IN 1960-1962

Product	No. of samples	Picocuries of strontium-90 per kilogram	
		Average	Range
Tea	159	390	19 -1,720
Coffee	120	16	0.9- 48
Cocoa beans	33	14	7.3- 25

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TABLE 7.—STRONTIUM-90 CONTENT OF SEA FOOD COLLECTED IN 1960-1962

Variety	No. of samples	Picocuries of strontium-90 per kilogram	
		Average	Range
Shellfish			
Oysters	26	1.1	0.0-9.8
Clams	21	0.7	0.0-4.6
Crustacea			
Crab	8	2.8	0.0-5.8
Shrimp	29	1.0	0.0-8.3
Lobster	12	0.6	0.0-1.5
Fish			
Sardine	86	1.6	0.0-8.1
Haddock	10	0.6	0.1-2.1
Salmon	6	0.6	0.0-1.4
Tuna	60	0.3	0.0-1.7
Bonita	14	0.3	0.0-1.0

TABLE 8.—STRONTIUM-90 CONTENT OF DAIRY PRODUCTS AND EGGS PRODUCED IN 1960-1962

Variety	No. of samples	Picocuries of strontium-90 per kilogram	
		Average	Range
Egg shell	21	407	39 -1,300
Cheese	59	50	11 - 140
Evaporated milk	25	26	2.1- 64
Egg substance	27	1.8	0.3- 3.8

TABLE 9.—STRONTIUM-90 CONTENT OF SHELLED NUTS HARVESTED IN 1961 AND 1962

Variety	No. of samples	Picocuries of strontium-90 per kilogram	
		Average	Range
Brazil nuts	9	63	18 -119
Peanuts	22	37	6.8- 81
Pecans	21	15	3.2- 50
Almonds	8	7.6	0.7- 19
Walnuts	11	2.5	0.0- 9.3
Cashew	16	2.2	0.0- 9.4

TABLE 10.—STRONTIUM-90 CONTENT OF SPICES, 1961-1962

Variety	No. of samples	Picocuries of strontium-90 per kilogram	
		Average	Range
Cinnamon	3	1180	531 -1,680
Thyme leaves	1	585	
Sage leaves	1	618	
Cassia	13	222	4.9-2,590
Cardamom	2	161	98 - 223
Caraway seed	7	96	19 - 206
Hops	5	49	32 - 159
Ginger	3	46	20 - 94
Mustard seed	18	37	8.8- 96
Chili peppers	8	17	1.9- 40

the highest content of strontium-90 of a particular group of foods or individual food, would the level of 200 pc have been approached or exceeded.

On September 1, 1961, the U.S.S.R. resumed nuclear testing, after approximately 2 years of moratorium. This was followed early in 1962 by a test program by the U.S. It became of interest to determine to what extent the injection of additional radioactive debris into the atmosphere would be reflected in this survey. The data were accordingly examined for this effect and, where enough samples were available, arranged in "before" and "after" columns. The results for selected crops appear in table 13. A doubling or more of the strontium-90 concentration can be observed in a number of foods, such as spinach and lettuce harvested after September 1, 1961. Some food items such as strawberries, snap beans, lima beans, and potatoes, actually exhibited less contamination on the average.

TABLE 11.—STRONTIUM-90 CONTENT OF BABY FOODS MANUFACTURED, 1960-1961

Variety	No. of varieties	No. of samples	Picocuries of strontium-90 per kilogram	
			Average	Range
Cereal products	6	40	11	0.1-49
Strained vegetables	7	33	7.0	0.8-25
Strained fruits	6	29	0.9	0.0- 3.9
Meat & poultry products	5	13	0.9	0.1- 2.7

It is quite clear that there is no evidence of a massive increase in fallout radionuclides in foods one year after the resumption of nuclear testing. In view of the relatively large increases in fallout noted one year after the December 1958 moratorium, the findings of this survey are difficult to explain. It should be noted that predictions based on meteorological data overestimated the spring 1962 fallout peak by a sizable margin. It is conjectured that the fallout peak associated with the 1961-62 test series may be delayed until spring 1963.

To compare the surveillance data for broad geographical fallout patterns, the continental U.S. was divided into western, central and eastern areas. The arrangement of the areas by States is given in figure 1. The listings of three categories where sufficient numbers of samples were available for a regional appraisal are included in figure 2. The latter figure also shows that fallout contamination tends to be greater in foods harvested in eastern and central regions, and lowest in the western.

Fallout has been shown to be largely influenced by the amount of rainfall (*5*). Since a large proportion of the western samples originated from irrigated regions of California and the Southwest, we may advance this as the most probable explanation for the generally lower level of contamination.

TABLE 12.—CONTRIBUTION OF SELECTED INDIVIDUAL AND GROUP FOODS TO THE DAILY INTAKE OF STRONTIUM-90, 1960-1962

Items	Strontium-90 concentration		Estimated daily intake		
				Strontium-90	
	Top of range[a] (pc/kg)	Average (pc/kg)	Grams	Top of range (pc)	Average (pc)
Dairy products[b]	140	43	[f]422	59	18
Grain products[c]	447	29	[f]220	100	6.4
Vegetables[d]	299	21	[f]184	55	3.8
Root vegetables	118	8.1	[f]360	42	2.9
Fruits[e]	110	5.8	[f]332	37	1.9
Oranges	27	11	[g]68	1.8	0.75
Lettuce	178	16	[g]33	5.9	0.48
Snap beans	98	18	[g]23	2.3	0.41
Cabbage	68	12	[g]28	1.9	0.28
White potatoes	12	2.4	[g]111	1.3	0.27
Onions	76	7.5	[g]28	2.1	0.21
Sweet potatoes	118	22	[g]7.7	1.0	0.19
Spices	2590	165	[f]0.75	1.2	0.17
Tea	1720	390	[h]0.3	0.5	0.12
Spinach	264	41	[g]3	0.78	0.12
Asparagus	38	6.2	[g]16	0.61	0.10
Egg substance	3.8	1.8	[g]43	0.18	0.09
Coffee	48	16	[i]5	0.24	0.08
Broccoli	100	23	[g]3	0.3	0.07
Tomatoes	11	1.9	[g]30	0.33	0.06
Peas	53	8.0	[g]6	0.32	0.05
Apples	7.0	1.5	[g]31	0.2	0.05
Strawberries	59	15	[g]3	0.18	0.04
Cucumber	17	5.3	[g]6	0.10	0.03
Peaches	12	3.3	[g]8	0.1	0.03
Grapefruit	16	5.1	[g]4	0.06	0.03
Sea food	9.8	0.9	[g]28	0.27	0.03
Cherries	16	6.1	[g]3	0.05	0.02
Bananas	0.5	0.2	[g]36	0.02	0.01
Peppers	11	2.6	[g]3	0.03	0.01

[a] The highest single strontium-90 concentration found in the entire series of analyses on the particular food item.

[b] Cheese, evaporated and dried milk only. Fresh milk not included in analyses.

[c] Whole grains only. Milled, processed derivatives not included in analyses.

[d] Exclusive of tomatoes and root vegetables.

[e] Inclusive of tomatoes.

[f] Food consumption of Households in the United States, U.S.D.A. Report No. 1, 1955; one-person household (all urbanizations).

[g] Prescribed annual and daily allowances of food groups in military composite ration for 1960 (see ref 6).

[h] Based on an estimated daily use of 1.5 grams tea leaves for making beverage and an estimate of 20% extraction of strontium-90.

[i] Based on military composite ration of 25 grams per day (*see ref. 6*) and an estimate of 20% extraction of strontium-90.

TABLE 13.—STRONTIUM-90 CONTENT OF AGRICULTURAL PRODUCTS HARVESTED BEFORE AND AFTER RESUMPTION OF ATMOSPHERIC TESTING

Variety	No. of samples	*Before:* 1960 to Sept. 1961 (Picocuries of strontium-90 per kilogram)		No. of samples	*After:* Sept. 1961 thru 1962 (Picocuries of strontium-90 per kilogram)	
		Average	Range		Average	Range
Strawberries	43	16	0.9-59	17	12	2.0- 37
Peaches	27	1.8	0.4- 7.3	41	4.3	0.4- 14
Tomatoes	45	1.4	0.1- 5.3	54	2.2	0.1- 11
Apples	25	1.1	0.1- 3.5	33	1.1	0.2- 7.0
Spinach	24	13	2.8-67	36	59	2.9-264
Soy beans	9	26	13 -42	23	49	11 -272
Lettuce	49	4.3	0.7-18	90	21	0.8-178
Celery	54	7.4	0.9-31	51	15	0.7- 56
Snap beans	62	20	2.0-98	40	14	0.3- 85
Cabbage	11	5.6	1.6-13	125	11	0.3- 78
Peas	22	4.4	0.7- 8.7	40	10	0.0- 43
Lima beans	11	8.5	2.7-28	27	4.5	0.4- 19
Onions	34	4.1	0.1-45	46	10	0.5- 70
Carrots	35	4.0	0.5-13	40	5.7	0.9- 25
Potatoes	25	2.9	0.7- 11	116	2.2	0.0- 12

Before any formal program with industrial participants was planned, an investigation was conducted to determine what effects such mechanical operations as washing, culling, peeling, and milling would have on the strontium-90 content of raw agricultural products. When certain raw products were sampled, the processed counterparts, either frozen or canned, were also analyzed. Each individual sample of a raw agricultural product was identified by lot number as the precursor of a particular processed sample. The results, shown in table 14, indicate that canning or freezing, together with the associated preparative mechanical operations, remove from 19 to 62 percent of

TABLE 14.—EFFECT OF PROCESSING ON THE STRONTIUM-90 CONTENT OF VEGETABLES AND FRUITS

Product	No. of paired samples	Picocuries strontium-90 per kilogram				Percent reduction
		Raw		Canned or frozen		
		Average	Range	Average	Range	
Spinach	34	23	2.8-96	18	1.8-90	22
Snap beans	38	16	1.1-98	6.1	0.4-30	62
Carrots	25	6.2	0.8-21	5.0	0.7-23	19
Tomatoes	41	1.4	0.1- 5.1	1.1	0.1- 4.6	21
Peaches	14	1.4	0.4- 4.0	0.7	0.1- 2.1	50

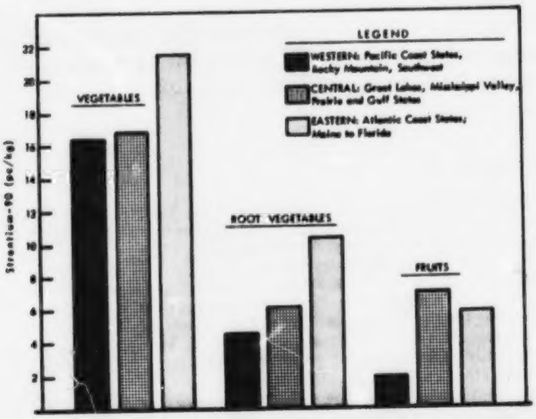

FIGURE 2.—REGIONAL DISTRIBUTION OF STRONTIUM-90 RAW AGRICULTURAL PRODUCTS IN THE U.S., 1960–1962

TABLE 15.—DISTRIBUTION OF STRONTIUM-90 IN CERTAIN AGRICULTURAL PRODUCTS

[Picocuries strontium-90 per kilogram]

Food type	Number of samples	Strontium-90	
		Average	Range
Wheat			
Berry	ᵃ38	22	3.8- 58
Bran	32	68	9.6- 168
Flour	38	4.4	0.6- 13
Rice			
Whole grain	10	4.9	1.1- 8.3
Milled	10	0.7	0.1- 1.7
Corn			
Whole grain	18	1.6	0.0- 4.6
Meal	18	1.3	0.0- 4.4
Beans, lima			
Bean	23	7.8	0.6- 28
Pod	23	39	3.7- 172
Apples			
Flesh	15	0.9	0.1- 2.6
Peel	8	1.4	0.6- 3.5
Core	14	3.8	0.8- 14
Eggs			
Substance	27	1.8	0.3- 3.8
Shell	21	407	39 -1,300

ᵃ Indicates number of paired or related samples.

strontium-90 from the raw product. Table 15 shows that there are some interesting differences in distribution of strontium-90 within many food parts. For example, milling, which separates the outer coat or branlike layer from grains, is also very effective in reducing the strontium-90 content. Unequal distribution of strontium-90 can also be seen in products like apples, lima beans and eggs, the latter most remarkably so, with egg shell containing over one hundred times as much as the egg substance. Here, the close association of strontium with calcium is obvious.

Cesium-137 of Individual Foods and Food Groups

Although fewer samples were analyzed for cesium-137 than for strontium-90 content, the results in table 16 show that the level of cesium-137 in foods is, on the average, about 5 times that of strontium-90 (of table 1). Cesium-137 distribution in the food chain is generally similar to that of strontium-90 as found in tea, spices, sea food, eggs, and root vegetables, but cesium-137 is relatively higher in such items as leafy vegetables.

Table 17 shows the estimated intakes of cesium-137. The Federal Radiation Council has not issued any guidance on daily intake of cesium-137 but one can deduce from maximum permissible concentrations, quoted in Handbook 69 of the National Committee on Radiation Protection, that a cesium-137 intake guide would be of the order of 4,000 pc per day.[2] Using this value for orientation, it can be seen in table 17 that the top of the range of cesium-137 concentrations recorded was as follows: vegetables, 1,020 pc; dairy products, 548 pc; root vegetables, 370 pc; fruits, 184 pc; and grain products, 138 pc. Thus, even in the unlikely situation of all food groups being contaminated to the maximum extent noted in table 17, the daily dietary intake level of 4,000 picocuries would not be observed.

Summary

Within the frame of reference indicated by the Federal Radiation Council, this survey has uncovered no foods which, on the basis of their daily intake of strontium-90 or cesium-137, would approach the suggested daily limits of intake. The first year following resumption of atmospheric testing was not marked by dramatic increases of strontium-90 in foods, although some sporadic higher concentrations were noted in leafy vegetables.

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[2] This figure represents a general population cesium-137 intake guide, estimated by dividing the 168-hour occupational (MPC)w by 100 and applying a daily intake of two liters of water.

Fallout contamination of foods ranks higher in eastern and central portions of the U.S. than in the West—an effect believed to be associated with the amount of rainfall.

Preliminary findings indicated that a variety of mechanical processing operations on raw foods are effective in reducing the strontium-90 concentration.

REFERENCES

(*1*) U.S. Atomic Energy Commission, New York Operations Office: *Health and Safety Laboratory Manual of Standard Procedures, NYO-4700:*E-38-01 (March 1957).

(*2*) Food and Drug Administration: Cesium-137 and Strontium-90 in Foods, 1960-1962, *Radiological Health Data 3:*80-5, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (February 1963).

(*3*) Turner, R. C. J. M. Radley, and W. V. Mayneord: The Naturally Occurring Alpha Ray Activity of Foods, *Health Physics 1:*268-75 (1958).

(*4*) Federal Radiation Council press release dated September 10, 1962.

(*5*) Federal Radiation Council: *Estimates and Evaluation of Fallout in the U.S. from Nuclear Weapons Testing Conducted through 1962, Report No. 4,* Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., (May 1963) price 30 cents.

(*6*) U.S. Army Subsistence Center: *Annual Food Plan for the Army/Air Force, 1960, In continental U.S.,* Attn: Chief, Menu Planning Div., 1819 W. Pershing Rd., Chicago.

TABLE 16.—CESIUM-137 CONTENT OF HUMAN FOODS PRODUCED AND HARVESTED IN 1960-1962

Type of food	No. of varieties	No. of samples	Picocuries of cesium-137 per kilogram	
			Average	Range
Leafy vegetables[1]	6	20	1,470	[15]N.D.-5,540
Tea[2]	2	20	1,290	210-4,960
Spices[3]	8	20	784	N.D.-3,150
Coffee[4]	2	7	431	320- 652
Legumes[5]	9	34	264	N.D.-1,940
Nuts[6]	6	34	246	N.D.-1,180
Cocoa beans	1	2	142	141- 142
Dairy products[7]	2	20	133	N.D.-1,300
Grains[8]	4	55	132	N.D.- 625
Brassicae[9]	3	17	124	N.D.-1,030
Rice	1	4	101	N.D.- 329
Grain products[10] (flour, meal, bran)	7	28	95	N.D.- 500
Root vegetables[11]	4	13	79	N.D.- 413
Fruits[12]	20	51	79	N.D.- 553
Corn	1	18	68	1.0- 142
Sea food[13]	7	27	50	N.D.- 205
White potatoes	1	14	38	N.D.- 291
Egg substance[14]	1	6	12	3- 27
Processed baby foods (junior)				
Strained meats	3	4	44	22- 65
Strained vegetables	4	6	33	3.6- 125
Strained fruits	1	1	2.6	
Organic calcium sources				
Egg shells	1	3	396	N.D.-1,170

[1] Lettuce, spinach, parsley, collards, celery, and mustard greens.

[2] Black and green tea.

[3] Cardamom, cassia, chili peppers, caraway seed, mustard seed, thyme leaves and dried hops.

[4] Ripe and green coffee beans.

[5] Dried red, pinto, snap, navy, green, lima, peas, kidney beans and soy beans.

[6] Almonds, Brazil nuts, cashews, peanuts, pecans and walnuts.

[7] Milk (non-fat dried milk) and cheeses (cheddar, cottage, etc.).

[8] Wheat, oats, barley and rye.

[9] Cabbage, Brussel sprouts and broccoli.

[10] Bran, flour, corn meal, oat flour, soybean meal and soya flour.

[11] Carrots, turnips, onions and sweet potatoes.

[12] Apples, apricots, bananas, cherries, cranberries, cucumbers, dates, figs grapes, grapefruit, nectarines, oranges, peaches, pears, pineapple, plums, pumpkin, squash, raspberries and tomatoes.

[13] Clams, crabmeat, haddock, lobster and lobster tails, sardines, shrimp and tuna fish.

[14] Without shells.

[15] ND indicates not detectable.

TABLE 17.—CONTRIBUTION OF SELECTED INDIVIDUAL AND GROUP FOODS TO THE DAILY INTAKE OF CESIUM-137

Item	Cesium-137 concentration		Estimated daily intake		
			Grams	Cesium-137	
	Top of range[a] (pc/Kg)	Average (pc/Kg)		Top of range (pc)	Average (pc)
Vegetables[b]	5,540	570	[f]184	1,020	105
Dairy products[c]	1,300	133	[f]422	548	56
Root vegetables	1,030	79	[f]360	370	28
Fruits[d]	553	79	[f]332	184	26
Grain products[e]	625	115	[f]220	138	25
White potatoes	291	38	[g]111	32	4.2
Coffee	652	431	[h]5	3.3	2.2
Sea food	205	50	[g]28	5.7	1.4
Spices	15,700	784	[i]0.75	11	0.59
Egg substance	27	12	[g]43	1.1	0.52
Tea	25,700	1,290	[i]0.3	7.5	0.39
Rounded sums			1,710	2,320	249

[a] The highest single cesium-137 concentration found in the entire series of analyses on the particular food item.

[b] Exclusive of tomatoes and root vegetables.

[c] Cheese, evaporated and dried milk only. Fresh milk not included in analyses.

[d] Inclusive of tomatoes.

[e] Whole grains only. Milled, processed derivatives not included in analyses.

[f] Prescribed annual and daily allowances of food groups in military composite ration for 1960 (*See* note h).

[g] Food Consumption of Households in the United States—1 person household (all urbanizations). U.S.D.A. Report #1 (1955).

[h] Based on an estimate of 20% extraction of cesium-137 and *Annual Food Plan for the Army/Air Force In Continental U.S., 1960,* U.S. Army Subsistence Center, Attn: Chief, Menu Planning Div., 1819 W. Pershing Rd., Chicago, Ill.

[i] Based on an estimated daily use of 1.5 grams tea leaves for making beverage and an estimate of 20% extraction of cesium-137.

SECTION III.—MILK

Milk Surveillance

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segement of the U.S. population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

PASTEURIZED MILK NETWORK
May 1963

Division of Radiological Health and
Division of Environmental Engineering and
Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program comprising 46 stations in July 1960. The 46 stations were selected to provide nationwide surveillance of milk production and consumption areas.

As further needs developed, more milk sampling points were added through July 1962, when the total number of stations reached was 62. Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. After collection, the composites are preserved with formaldehyde and are sent for analysis to the Southwestern, Southeastern, or Northeastern Radiological Health laboratories of the Public Health Service. Approximately 3–6 days after sample collection, any results from the gamma analyses for iodine–131 which indicate concentrations of this radionuclide greater than 100 pc/liter are made available to States for possible public health action. Complete analytical results are available 6 to 7 weeks after sample collection; publication in *Radiological Health Data* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method of compositing specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's sales in the community served. At most stations, the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, sampling was done twice a

TABLE 1.—RADIOACTIVITY IN PASTEURIZED MILK, MAY 1963

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month
Ala:	Montgomery	1.26	1.22	85	130	18	26	<10	<10	50	100	10	<10
Alaska:	Palmer	1.19	1.16	20	30	11	14	10	<10	65	50	10	<10
Ariz:	Phoenix	1.20	1.18	20	30	4	6	<10	<10	20	20	<10	<10
Ark:	Little Rock	1.23	1.22	125	215	34	51	20	<10	90	210	20	<10
Calif:	Sacramento	1.23	1.21	25	130	4	26	10	<10	30	95	10	<10
	San Francisco	1.26	1.21	85	200	8	25	10	<10	35	125	10	<10
Colo:	Denver	1.29	1.24	15	20	11	12	20	<10	65	55	<10	<10
Conn:	Hartford	1.11	1.09	<5	30	12	19	<10	<10	65	110	<10	<10
Del:	Wilmington	1.13	1.00	5	65	17	31	<10	<10	70	120	<10	<10
D.C:	Washington	1.22	1.16	10	120	15	25	<10	<10	60	110	<10	<10
Fla:	Tampa	1.24	1.20	50	40	14	14	20	<10	135	200	<10	<10
Ga:	Atlanta	1.24	1.20	100	190	21	36	10	<10	85	190	20	<10
Hawaii:	Honolulu	1.14	1.12	55	75	8	10	20	<10	55	65	10	<10
Idaho:	Idaho Falls	1.25	1.20	10	60	11	16	10	<10	75	85	<10	<10
Ill:	Chicago	1.13	1.02	<5	25	16	19	<10	<10	70	70	<10	<10
Ind:	Indianapolis	1.15	1.05	10	70	16	35	<10	<10	60	100	<10	<10
Iowa:	Des Moines	1.23	1.20	15	200	14	41	10	<10	65	110	10	<10
Kans:	Wichita	1.25	1.18	20	60	12	20	10	<10	50	60	10	<10
Ky:	Louisville	1.22	1.20	35	175	20	34	<10	<10	55	110	<10	<10
La:	New Orleans	1.27	1.27	265	170	37	40	20	<10	120	180	30	<10
Maine:	Portland	1.14	1.01	<5	20	20	25	<10	<10	105	120	<10	<10
Md:	Baltimore	1.23	1.16	5	120	14	26	<10	<10	65	130	<10	<10
Mass:	Boston	1.14	1.02	<5	30	19	23	<10	<10	95	120	<10	<10
Mich:	Detroit	1.16	1.08	<5	20	18	21	<10	<10	75	75	<10	<10
	Grand Rapids	1.16	1.07	5	20	15	16	10	<10	75	80	<10	<10
Minn:	Minneapolis	1.20	1.20	15	50	17	24	10	<10	110	100	10	<10
Miss:	Jackson	1.33	1.29	230	205	32	38	20	<10	80	145	30	<10
Mo:	Kansas City	1.23	1.26	25	170	14	40	<10	<10	50	105	10	<10
	St. Louis	1.24	1.18	20	125	11	28	10	<10	60	95	20	<10
Mont:	Helena	1.18	1.26	20	65	13	20	10	<10	90	100	20	<10
Nebr:	Omaha	1.25	1.24	20	120	14	30	10	<10	65	80	10	<10
Nev:	Las Vegas	1.18	1.16	10	25	6	9	<10	<10	45	40	10	<10
N.H.:	Manchester	1.16	1.07	<5	30	18	24	10	<10	110	180	<10	<10
N.J:	Trenton	1.14	1.03	<5	40	13	25	<10	<10	65	105	<10	<10
N. Mex:	Albuquerque	1.23	1.15	15	40	4	10	<10	<10	30	35	10	<10
N.Y:	Buffalo	1.11	1.03	5	30	16	21	<10	<10	85	90	<10	<10
	New York	1.12	1.05	<5	25	16	22	<10	<10	65	90	<10	<10
	Syracuse	1.12	1.05	<5	25	13	21	<10	<10	65	80	<10	<10
N.C:	Charlotte	1.27	1.30	30	140	22	32	<10	<10	60	120	<10	<10
N. Dak:	Minot	1.21	1.20	15	190	23	56	<10	<10	85	100	20	<10
Ohio:	Cincinnati	1.11	1.03	15	80	17	35	<10	<10	55	90	<10	<10
	Cleveland	1.12	1.07	<5	40	14	24	<10	<10	60	80	<10	<10
Okla:	Oklahoma City	1.23	1.20	60	165	20	30	20	<10	55	125	10	<10
Ore:	Portland	1.25	1.24	55	210	11	48	<10	<10	70	180	20	<10
Pa:	Philadelphia	1.13	1.02	5	70	18	30	<10	<10	65	180	<10	<10
	Pittsburgh	1.13	1.06	5	45	18	22	<10	<10	80	100	<10	<10
P.R:	San Juan	1.20	1.17	135	100	12	19	20	<10	65	130	20	<10
R.I:	Providence	1.13	1.01	5	45	16	29	<10	<10	75	115	<10	<10
S.C:	Charleston	1.26	1.25	105	140	23	28	20	<10	80	110	20	<10
S. Dak:	Rapid City	1.00	0.92	25	100	13	27	10	<10	80	90	<10	<10
Tenn:	Chattanooga	1.29	1.22	75	235	23	48	<10	<10	65	165	10	<10
	Memphis	1.26	1.23	100	190	23	41	10	<10	50	110	20	<10
Tex:	Austin	1.22	1.12	50	50	8	8	10	<10	30	45	<10	<10
	Dallas	1.25	1.16	110	140	20	28	20	<10	60	110	20	<10
Utah:	Salt Lake City	1.26	1.22	15	30	12	19	10	<10	100	90	10	<10
Vt:	Burlington	1.11	1.04	<5	25	16	19	<10	<10	85	100	<10	<10
Va:	Norfolk	1.25	1.20	30	95	17	28	<10	<10	65	120	<10	<10
Wash:	Seattle	1.24	1.17	30	190	10	35	10	<10	75	190	10	<10
	Spokane	1.31	1.32	15	160	12	36	10	<10	85	150	10	<10
W. Va:	Charleston	1.23	1.18	15	180	19	40	<10	<10	50	115	<10	<10
Wis:	Milwaukee	1.14	1.04	10	20	11	22	<10	<10	65	75	<10	<10
Wyo:	Laramie	1.24	1.24	20	70	12	23	<10	<10	95	105	20	<10
Network average		1.20	1.15	37	95	15.6	26.5	<10	<10	70	107	<10	<10

week at nearly all stations, and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention. Sampling frequency and schedules of analyses are adjusted to meet changing conditions.

Analytical Errors in Radionuclide Measurements

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy,[1] while strontium-89 and strontium-90 concentrations are determined by radiochemical

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

TABLE 2.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, MAY 1963

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5- 30	17	<1- 8	2	<10	62	<5- 40	3	<10	62
35- 60	10	9-16	8			45- 80	12		
65- 90	7	17-24	19			85-120	32		
95-120	7	25-32	17			125-160	8		
125-150	5	33-40	10			165-200	6		
155-180	6	41-48	4			205-240	1		
185-210	8	49-56	2						
>210	2								

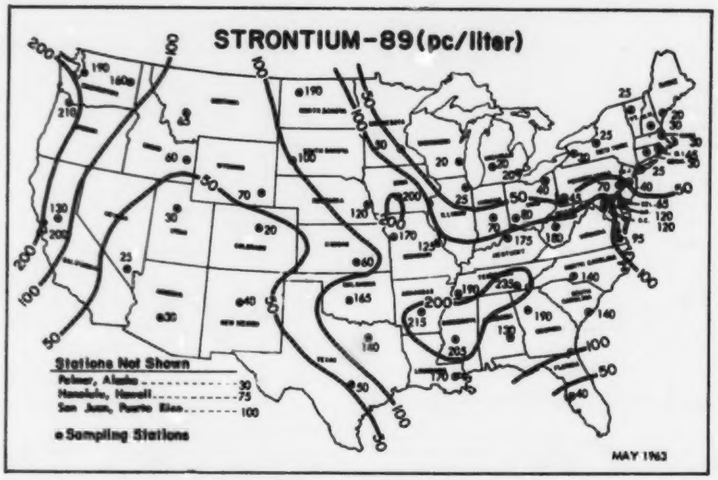
STRONTIUM-89(pc/liter)
Stations Not Shown
Palmer, Alaska 30
Honolulu, Hawaii 75
San Juan, Puerto Rico 100
● Sampling Stations
MAY 1963

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK, MAY 1963

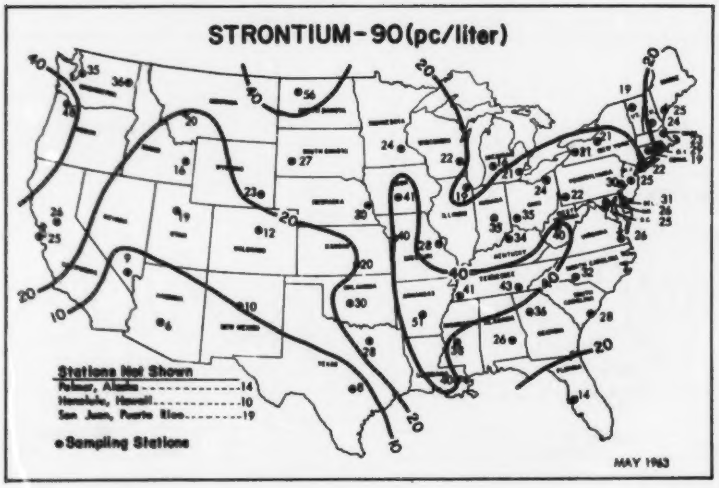
STRONTIUM-90(pc/liter)
Stations Not Shown
Palmer, Alaska 14
Honolulu, Hawaii 10
San Juan, Puerto Rico 19
● Sampling Stations
MAY 1963

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, MAY 1963

procedures. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation is relatively high. The variation is dependent upon the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. The minimum detectable concentration is defined as that concentration at which the statistical two-standard-deviation analytical error is 100 percent of the measured concentration (*1*). Accordingly the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10: Cs^{137}, 5; and Ba^{140}, 10.

Data Presentation

Table 1 presents summaries of the analyses for May 1963 (April 28–May 25, 1963). When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average.

Although no data are presented on the stable potassium concentrations in milk, analysis has

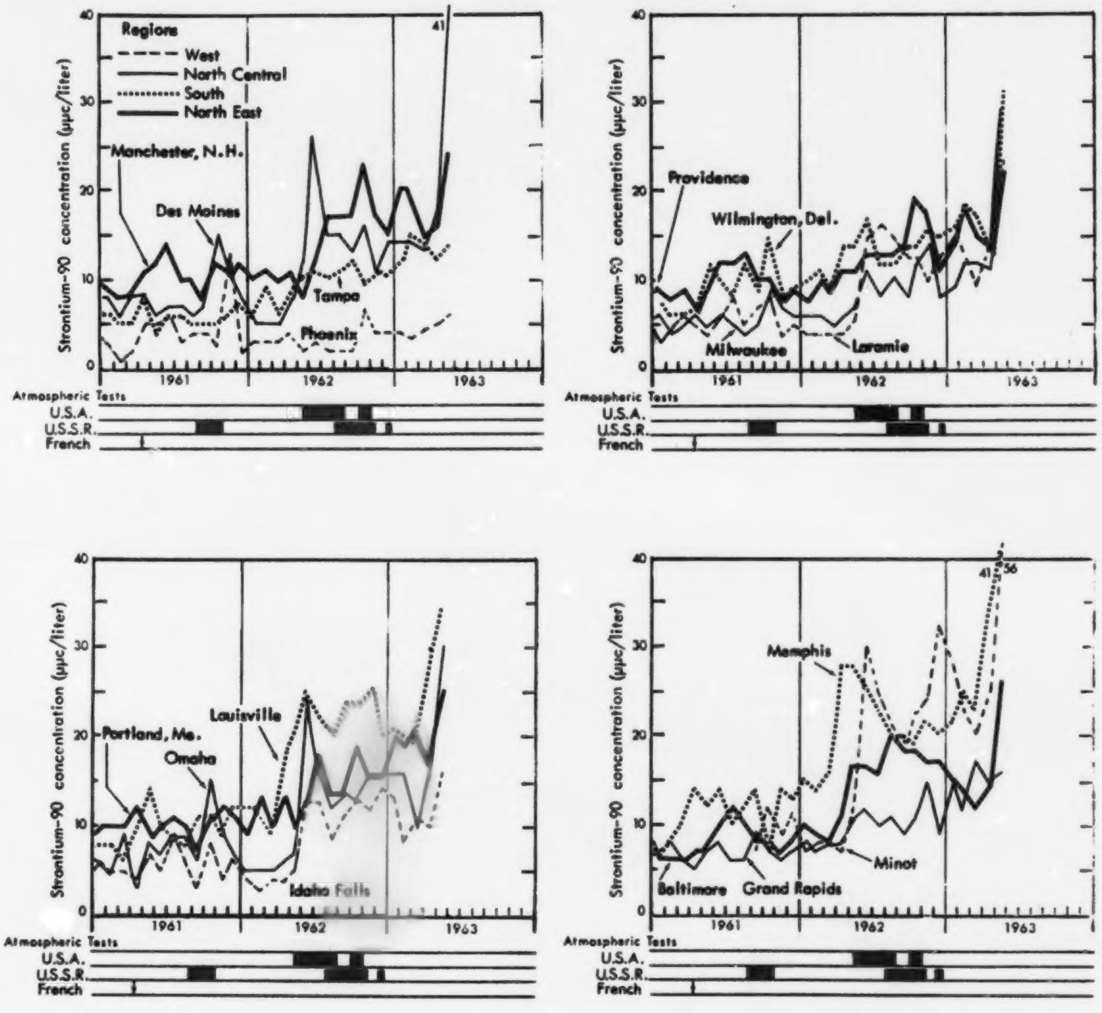

FIGURE 3.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, 1961–MAY 1963

indicated that the usual range of concentrations is from 1.3 to 1.8 grams/liter. In May, for example, 2, 22, 11, 23, 3, and 1 stations recorded respective monthly average potassium concentrations of 1.3, 1.4, 1.5, 1.6, 1.7 and 1.8 grams/liter. One station recorded 1.1 grams/liter.

Figures 1 and 2 are isoconcentration maps showing the estimated radionuclide concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. In order to show numerically the distribution of the network's stations versus radionuclide concentrations in milk, table 2 has been prepared using the monthly average data shown in table 1.

Selected Monthly Strontium-90 Profiles

Continuing the practice followed in previous issues of RHD, the average monthly strontium-90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented (see figure 3). Each individual graph shows the strontium-90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions. This method of selection permits the graphical presentation of data for each city in the network at least twice a year.

REFERENCE

(*1*) Division of Radiological Health, Public Health Service: Pasteurized Milk Network, February 1963, *Radiological Health Data*, 4:291-6, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (June 1963).

INDIANA MILK NETWORK
May 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 4).

The milk samples are routinely analyzed for iodine-131, cesium-137, barium-140, strontium-89, and strontium-90. Analyses for the gamma emitters iodine-131, cesium-137, and barium-140 are conducted on a weekly basis except when iodine-131 results exceed 100 pc/liter, at which time the frequency of sampling is increased. Strontium-89 and strontium-90 analyses are performed monthly on samples which are composited from weekly aliquots.

The ion exchange analytical procedure (*1*) is used for strontium-89 and strontium-90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine-131, cesium-137, and barium-140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 3. The State average is an arithmetic average of the station values.

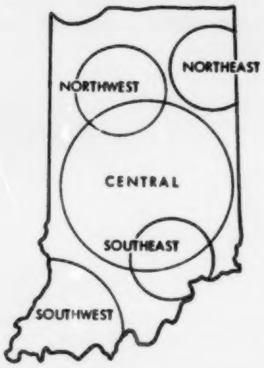

FIGURE 4.—INDIANA MILK SAMPLING LOCATIONS

TABLE 3.—RADIONUCLIDES IN INDIANA MILK, MAY 1963

[Concentrations in pc/liter]

Sampling location	Strontium -89	Strontium -90	Iodine -131	Cesium -137	Barium -140
Northeast	85	24	<10	90	<10
Southeast	100	34	<10	100	<10
Central	90	30	<10	85	<10
Southwest	40	32	<10	70	<10
Northwest	90	28	<10	105	<10
State average	80	30	<10	90	<10

REFERENCE

(*1*) Porter C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry 33*:1306-8 (September 1961).

NEW YORK MILK NETWORK
April 1963

Division of Environmental Health Services
State of New York Department of Health

Milk samples, collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 5), are analyzed for radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium-89, strontium-90, iodine-131 and cesium-137 at all stations except Massena, where samples are composited bi-weekly and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed for iodine-131 daily. In the event that any city reports iodine-131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

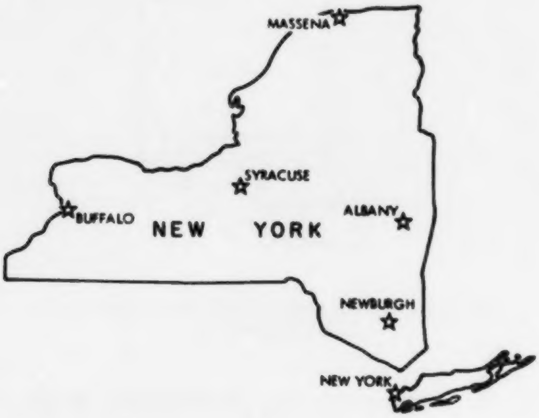

FIGURE 5.—NEW YORK MILK SAMPLING LOCATIONS

The matrix method (*1*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

TABLE 4.—RADIONUCLIDES IN NEW YORK MILK, APRIL 1963

[Concentrations in pc/liter]

Sampling location	Strontium -89	Strontium -90	Iodine -131	Cesium -137
Albany	4	8	<20	49
Buffalo	7	7	<20	37
Massena	5	9	<20	73
Newburgh	13	7	<20	23
New York City	9	8	23	<20
Syracuse	5	6	<20	<20

The analytical procedure for strontium-89 and strontium-90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm² window. The strontium-90 portion is differentially estimated by a second count 40 hours later to determine the rate of growth of its daughter product, yttrium-90. The monthly average radionuclide concentrations in milk are shown in table 4.

REFERENCE

(*1*) Kahn, B., et al.: *Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Publication No. 999-R-2,* (March 1963). Single copies available on request.

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OREGON MILK NETWORK
March–June 1963

Division of Sanitation and Engineering
Oregon State Board of Health

The Oregon State Board of Health conducts milk monitoring at eight major milk-producing centers throughout the State of Oregon, as shown in figure 6. The half-gallon samples of packaged milk are collected on a monthly basis State-wide by the Oregon Department of Agriculture and weekly in the Portland area by the City of Portland. Milk sampling frequency is accelerated to a weekly schedule at those locations having milk concentrations in excess of 100 pc/liter for iodine-131 or 500 pc/liter for cesium-137 (suggestive of elevated strontium-90 concentrations). The samples are forwarded to the Oregon State Board of Health radiation laboratory for iodine-131, cesium-137, and barium-140 analyses. Gamma analyses are performed utilizing a 3" x 3" sodium iodide scintillation crystal and a 512-channel pulse-height analyzer system. Samples are normally counted for 100 minutes. The minimum detectable concentrations for iodine-131, cesium-137, and barium-140 are 15 pc/liter. The minimum detectable concentration is defined to be that amount of activity which, in the same counting time, will exceed the background by 3σ (counting error) of the background.

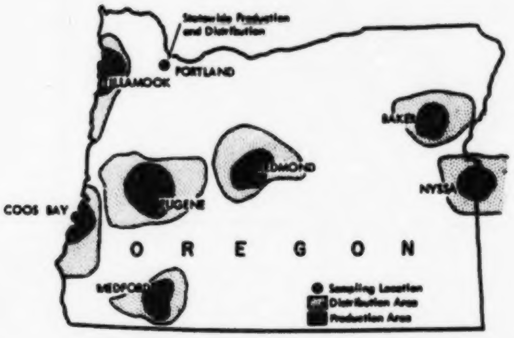

FIGURE 6.—OREGON PASTEURIZED MILK NETWORK SAMPLING LOCATIONS SHOWING PRODUCTION AND DISTRIBUTION AREAS

To maintain a check on the analytical procedures and instrument calibration, a portion of the official U.S. Public Health Service composite pasteurized milk sample from Portland is obtained on a weekly basis for analysis. The cesium-137 data are compared with the Public Health Service data in figure 7.

Table 5 presents the Oregon milk surveillance data on iodine-131, cesium-137 and barium-140 for March through June 1963. The Portland composite sample represents contributions from nearly all milksheds in Oregon, plus some in Washington State. During the period reported, iodine-131 again became detectable. The fact that iodine-131 was detectable is supported by results of analyses of a May 8 milk sample from Coos Bay that was analyzed by both the Oregon State Board of Health and the Public Health Service. Iodine-131 concentrations of 30 and 20 pc/liter were reported, respectively.

During heavy coastal rains in April, cesium-137 concentrations began to increase, reaching a peak during May at most Oregon milk sampling locations. Following the increased cesium-137 concentrations during April, weekly sampling of milk

TABLE 5.—IODINE-131, CESIUM-137, AND BARIUM-140 CONCENTRATIONS IN OREGON MILK, MARCH-JUNE 1963

[Average concentrations in pc/liter]

Sampling location	Iodine-131				Cesium-137				Barium-140			
	Mar.	Apr.	May	Jun.	Mar.	Apr.	May	Jun.	Mar.	Apr.	May	Jun.
Baker	<15	<15	<15	20	50	50	90	205	<15	<15	<15	<15
Coos Bay	<15	40	40	15	65	340	460	240	<15	<15	<15	<15
Eugene	<15	<15	15	<15	55	65	200	165	<15	<15	<15	<15
Medford	<15	15	<15	20	50	95	200	220	<15	<15	20	<15
Nyssa	<15	<15	<15	<15	45	55	85	170	<15	<15	<15	<15
Portland (composite)	<15	20	<15	15	75	130	215	190	<15	<15	<15	<15
Portland (Local Producer)	<15	20	15	<15	70	125	235	175	<15	<15	20	<15
Redmond	<15	<15	20	<15	60	60	105	105	<15	<15	<15	<15
Tillamook	<15	20	20	20	85	215	380	305	<15	<15	15	<15

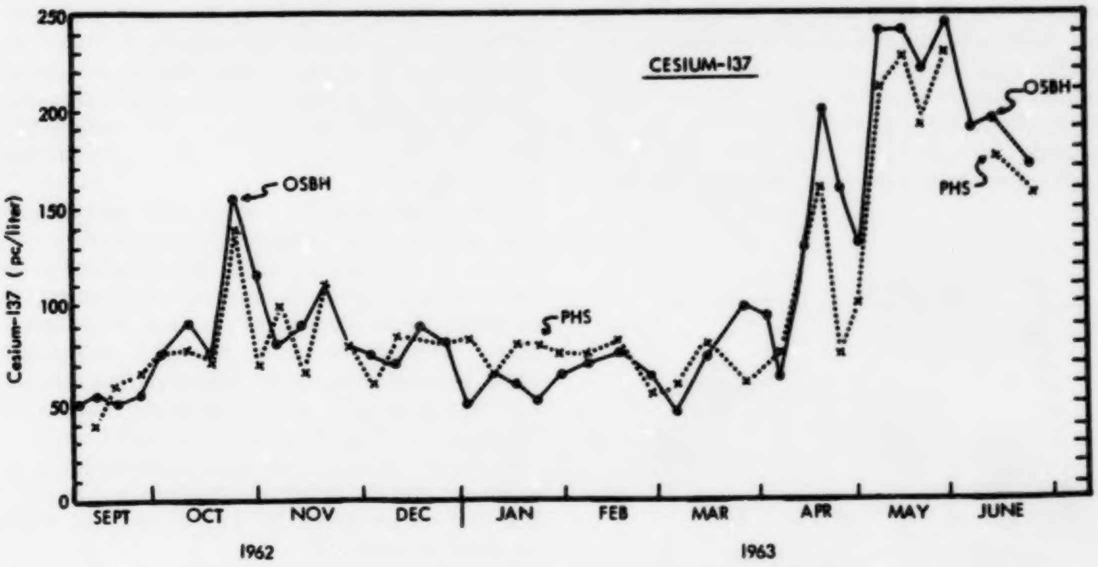

FIGURE 7.—COMPARISON OF PUBLIC HEALTH SERVICE AND OREGON STATE BOARD OF HEALTH SPLIT MILK SAMPLE ANALYSES FOR PORTLAND, OREGON

TABLE 6.—STRONTIUM-89 AND STRONTIUM-90 CONCENTRATIONS IN OREGON MILK, MARCH-MAY 1963

[Average concentrations in pc/liter]

Sampling location	Strontium-89			Strontium-90		
	Mar.	Apr.	May	Mar.	Apr.	May
Coos Bay			885			162
Portland (composite)	55		210	12		48
Tillamook			435			74

was initiated in the first week in May at Coos Bay and Tillamook, where the highest concentrations of cesium-137 in the State were observed. Samples from these stations were shipped to the Public Health Service for radiostrontium analysis. The data in table 6 indicate that significant increases in strontium-89 and strontium-90 concentrations occurred in May.

CANADIAN MILK NETWORK[1]

April 1963

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

In January 1963, the Canadian Department of National Health and Welfare substituted the radioanalysis of fresh liquid milk for the analysis of powdered milk. The Department analyzed milk powders from November 1955 through December 1962, but liquid whole milk had been monitored since April 1962 for iodine-131 only.

With this change, it has been possible to choose milk sampling locations in the same areas as the air and precipitation stations. This permits the observation of a number of environmental variables which may effect the radionuclide levels in milk. In addition, it is now possible to report radionuclide concentrations in terms of the activity per liter of milk as well as per gram of calcium in milk.

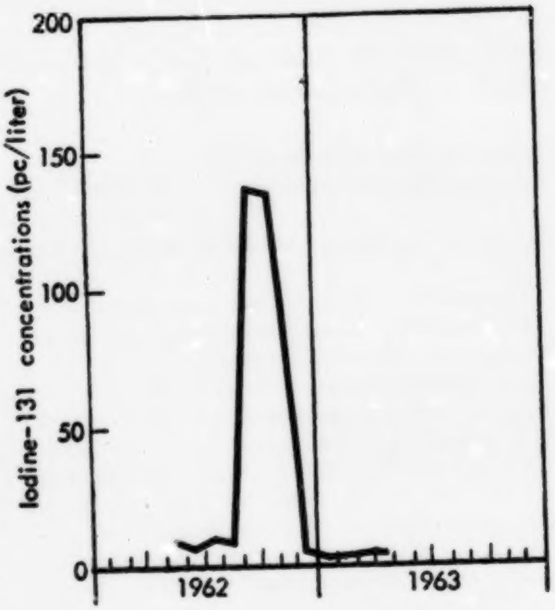

FIGURE 8.—IODINE-131 CONCENTRATIONS IN WHOLE MILK

TABLE 7.—RADIONUCLIDES IN CANADIAN WHOLE MILK, APRIL 1963

Station	Calcium (g/liter)	Strontium-89 (pc/liter)	Strontium-90 (pc/liter)	Iodine-131 (pc/liter)	Cesium-137 (pc/liter)
Calgary	1.25	24	19.0	0	82
Edmonton, Alta	1.23	20	16.2	—[a]	89
Fort William	1.20	7	23.5	—	106
Fredericton	1.30	9	31.6	—	172
Halifax	1.26	9	22.7	1	160
Montreal	1.21	12	12.3	—	64
Ottawa	1.21	9	10.3	5	49
Quebec	1.20	7	21.2	3	117
Regina	1.19	12	17.3	—	56
Saint John's, Nfld	1.21	15	18.9	—	94
Saskatoon	1.24	55	16.0	1	50
Sault Ste. Marie	1.19	13	14.2	1	60
Toronto	1.25	15	8.7	—	64
Vancouver	1.27	91	23.6	3	152
Windsor	1.26	14	9.6	2	48
Winnipeg	1.21	14	14.1	1	67
Average	1.23	20	17.5	2	80

[a] A dash indicates no analysis is made for these cities.

A detailed discussion of the sampling and radiochemical procedures employed for milk analyses may be found in the Department's publications (*1, 2*). Table 7 presents the results of the measurements of strontium-89, strontium-90, cesium-137, and iodine-131 in Canadian liquid whole milk for April. Figure 8 shows the iodine-131 variation since April 1962.

It should be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the concentration levels in a particular medium with the so-called Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*3*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period, such as one year, represent a better basis for comparison than do individual levels at any specific time.

REFERENCES

(*1*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurement of Radioactive Strontium in Canadian Milk Powder Samples, CNHW-RP-1*, (July (1958).

(*2*) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, RPD-5*, Radiation Protection Division, Department of National Health and Welfare (June 1, 1960).

(*3*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

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[1] Data from *Radiation Protection Programs*, Radiation Protection Division, Canadian Department of National Health and Welfare.

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Twelve-Month Sum of Daily Radionuclide Content of One Liter of Pasteurized Milk

Iodine–131: July 1962–June 1963
Strontium–89 and Strontium–90: June 1962–May 1963

Division of Radiological Health, Public Health Service

The guidance of the Federal Radiation Council (FRC) is given in terms of transient rates of intake of radioactive materials in picocuries per day. The action ranges proposed in FRC Report No. 2 are based on radiation doses considered acceptable for lifetime exposure from normal peacetime atomic industry operations (*1*). The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures and emphasizes that the annual acceptable exposure dose is not a "danger point" which, if exceeded, requires protective measures (*1, 2, 3*).

To facilitate comparison of the concentrations of certain radionuclides in milk with the Radiation Protection Guides, tables 1 and 2 furnish estimates of the contribution of milk to the total dietary intake of iodine–131, strontium–89, and strontium–90. The tables are developed from the PHS Pasteurized Milk Network monthly averages of the radionculides. The index values are estimated sums of the daily amounts of a radionuclide in one liter of milk for a 12-month period.

The tables show 12-month index values for each of the Network's 62 sampling locations. Due to the longer time required for strontium–89 and strontium–90 analysis, these 12-month index values are for the year beginning one month earlier than the iodine–131 values. The columns (B and C) of monthly index values in each table are used to compute the net change as the yearly index values are advanced by one month. Column D shows this new 12-month index value. In addition, the second column in table 1 gives the average iodine–131 concentrations for June 1963.

The data in tables 1 and 2 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly averages for all weeks ending within a given month are averaged and an average for the month is obtained, and (c) the monthly radionuclide index value is determined by multiplying the average for the month by the number of days in the month. The number of days in the month will be either 28 or 35, corresponding to the complete calendar weeks ending in a given month. Procedures exemplified by (a) and (b) above tend to minimize the effect of any one day's sample results on the average for the month, particularly for a short-lived radionuclide such as iodine–131. The yearly index values are obtained by the following procedure. Column (A) gives the twelve-month index values for the periods indicated. Columns (B) and (C) show the monthly index values for the periods indicated. The values in column (D) are obtained by adding the values in column (C) to those in column (A) and subtracting those in (B).

For a number of reasons, it is desirable to use a standard quantity of milk in the development of index values for the different radionuclides. When one is concerned with radio-strontium, 1 liter is a suitable quantity, as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the daily intake guidance for radiostrontium. When one is concerned with iodine–131, the critical age group is the young infant. Available information suggests that the average milk consumption of infants in the 6–18-month group is not more than 1 liter per day (*4, 5*). Thus, the index value based on 1 liter of milk, though not directly an average intake value, is probably the most useful index for estimating total intake.

REFERENCES

(*1*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*. Superintendent of Documents, U.S. Government Printing Office (September 1961), price 20 cents.

(*2*) Chadwick, Donald R., and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data*, *3*:159–65, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (May 1962).

(*3*) Public Health Service: Special Report, *Radiological Health Data*, *3*:ii–iii, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (September 1962).

(*4*) U.S. Department of Agriculture: *Food, The Yearbook of Agriculture, 1959*, pp. 283–95, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (1959).

(*5*) Public Health Service: Consumption of Selected Food Items in U.S. Households, July 1962. *Radiological Health Data*, *4*:124–9, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (March 1963).

TABLE 1.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

[pc day/liter]

Sampling locations		June 1963 iodine-131 averages (pc/liter)	Iodine-131 index values[a]			
			June 1962–May 1963 (A)	May 27–June 30, 1962 (B)	May 26, 1963–June 29, 1963 (C)	July 1962–June 1963 (D)
Ala:	Montgomery	<10	6,170	180	180	6,170
Alaska:	Palmer	<10	38,050	1,050	180	37,180
Ariz:	Phoenix	<10	4,160	350	180	3,990
Ark:	Little Rock	<10	14,420	700	180	13,900
Calif:	Sacramento	<10	4,630	350	180	4,460
	San Francisco	<10	4,630	180	180	4,630
Colo:	Denver	<10	6,100	[d]180	180	6,100
Conn:	Hartford	<10	7,670	350	180	7,500
Del:	Wilmington	<10	11,870	700	180	11,350
D.C:	Washington	<10	8,440	350	180	8,270
Fla:	Tampa	<10	6,660	350	180	6,490
Ga:	Atlanta	<10	8,900	180	180	8,900
Hawaii:	Honolulu	<10	4,590	350	180	4,420
Idaho:	Idaho Falls	<10	9,070	1,050	180	8,200
Ill:	Chicago	<10	12,710	1,050	180	11,840
Ind:	Indianapolis	<10	11,870	1,050	180	11,000
Iowa:	Des Moines	<10	19,290	2,450	180	17,020
Kans:	Wichita	<10	15,720	4,550	180	11,350
Ky:	Louisville	<10	10,120	700	180	9,600
La:	New Orleans	<10	10,190	350	180	10,020
Maine:	Portland	<10	8,160	350	180	7,990
Md:	Baltimore	<10	8,270	180	180	8,270
Mass:	Boston	<10	7,950	350	180	7,780
Mich:	Detroit	<10	12,690	180	180	12,690
	Grand Rapids	<10	9,730	350	180	9,560
Minn:	Minneapolis	<10	12,430	1,050	180	11,560
Miss:	Jackson	<10	9,720	350	180	9,550
Mo:	Kansas City	<10	24,610	8,400	180	16,390
	St. Louis	<10	11,660	2,100	180	9,740
Mont:	Helena	<10	13,970	1,050	180	13,100
Nebr:	Omaha	<10	18,520	2,800	180	15,900
Nev:	Las Vegas[b]	<10	4,870	[c]—	180	5,050
N.H:	Manchester	<10	7,710	180	180	7,710
N.J:	Trenton	<10	7,990	180	180	7,990
N. Mex:	Albuquerque	<10	5,960	180	180	5,960
N.Y:	Buffalo	<10	8,720	350	180	8,550
	New York	<10	11,240	350	180	11,070
	Syracuse	<10	9,730	700	180	9,210
N.C:	Charlotte	<10	3,370	350	180	3,200
N. Dak:	Minot	<10	14,490	700	180	13,970
Ohio:	Cincinnati	<10	14,180	700	180	13,660
	Cleveland	<10	11,100	350	180	10,930
Okla:	Oklahoma City	<10	17,960	5,600	180	12,540
Ore:	Portland	<10	9,770	1,050	180	8,900
Pa:	Philadelphia	<10	10,820	350	180	10,650
	Pittsburgh	<10	14,810	1,050	180	13,940
P.R:	San Juan[d]	<10	5,710	700	180	5,190
R.I:	Providence	<10	8,160	350	180	7,990
S.C:	Charleston	<10	7,180	180	180	7,180
S. Dak:	Rapid City	<10	14,150	180	180	14,150
Tenn:	Chattanooga	<10	7,430	180	180	7,430
	Memphis	<10	10,050	350	180	9,880
Tex:	Austin	<10	11,040	180	180	11,040
	Dallas	<10	18,560	1,050	180	17,690
Utah:	Salt Lake City	10	31,920	350	350	31,920
Vt:	Burlington	<10	8,380	180	180	8,380
Va:	Norfolk	<10	6,270	350	180	6,100
Wash:	Seattle	<10	9,770	350	180	9,600
	Spokane	<10	21,390	12,250	180	9,320
W. Va:	Charleston	<10	6,550	700	180	6,030
Wis:	Milwaukee	<10	14,320	700	180	13,800
Wyo:	Laramie	<10	19,120	700	180	18,600

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[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual iodine-131 intake per person from milk may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month I^{131} index × milk consumption factor = 12-month I^{131} intake
(pc day/liter) (liter/day/person) (pc/person)

[b] Station included in network in July 1962. The sum in column A is therefore for 11 months.
[c] A dash indicates no analysis.
[d] No sample was received for November 1962. The sums in columns A and D are therefore for 11 months.

TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-89 AND STRONTIUM-90 IN ONE LITER OF MILK

Sampling locations		Strontium-89 index values (pc day/liter)[a]				Strontium-90 index values (pc day/liter)[a]			
		May 1962–Apr. 1963 (A)	May 1962 (B)	Apr. 28, 1963–May 25, 1963 (C)	June 1962–May 1963 (D)	May 1962–Apr. 1963 (A)	May 1962 (B)	Apr. 28, 1963–May 25, 1963 (C)	June 1962–May 1963 (D)
Ala:	Montgomery	21,665	2,520	3,640	22,785	5,838	476	728	6,090
Alaska:	Palmer	19,985	1,120	840	19,705	4,207	224	392	4,375
Ariz:	Phoenix	6,425	280	840	6,985	1,267	56	168	1,379
Ark:	Little Rock	44,905	5,040	6,020	45,885	12,047	1,120	1,428	12,355
Calif:	Sacramento	10,380	840	3,640	13,180	1,848	140	728	2,436
	San Francisco	20,405	1,680	5,600	24,325	2,996	252	700	3,444
Colo:	Denver	11,200	560	560	11,200	4,123	168	336	4,291
Conn:	Hartford	8,070	280	840	8,630	4,214	252	532	4,494
Del:	Wilmington	12,235	1,400	1,820	12,655	5,425	392	868	5,901
D.C:	Washington	13,440	1,400	3,360	15,400	6,041	420	700	6,321
Fla:	Tampa	12,110	700	1,120	12,530	4,165	280	392	4,277
Ga:	Atlanta	27,440	3,220	5,320	29,540	7,287	560	1,008	7,735
Hawaii:	Honolulu	11,305	840	2,100	12,565	2,254	140	280	2,394
Idaho:	Idaho Falls	9,555	420	1,680	10,815	4,039	140	448	4,347
Ill:	Chicago	11,010	840	700	10,870	5,089	336	532	5,285
Ind:	Indianapolis	14,070	1,540	1,960	14,490	5,614	504	980	6,090
Iowa:	Des Moines	25,270	2,520	5,600	28,350	5,530	336	1,148	6,342
Kans:	Wichita	18,270	2,380	1,680	17,570	4,655	308	560	4,907
Ky:	Louisville	29,960	3,080	4,900	31,780	8,204	588	952	8,568
La:	New Orleans	55,440	6,160	4,760	54,040	12,110	952	1,120	12,278
Maine:	Portland	10,800	280	560	11,080	5,964	280	700	6,384
Md:	Baltimore	12,425	1,260	3,360	14,525	5,936	476	728	6,188
Mass:	Boston	11,480	420	840	1,850	6,797	336	644	7,105
Mich:	Detroit	9,995	700	560	9,855	5,117	280	588	5,425
	Grand Rapids	8,770	560	560	8,770	4,305	308	448	4,445
Minn:	Minneapolis	21,000	1,540	1,400	20,860	7,119	308	672	7,483
Miss:	Jackson	52,465	4,900	5,740	53,305	9,744	924	1,064	9,884
Mo:	Kansas City	31,430	3,360	4,760	32,830	5,971	476	1,120	6,615
	St. Louis	20,090	2,800	3,500	20,790	5,285	392	784	5,677
Mont:	Helena	17,395	1,260	1,820	17,955	5,292	308	560	5,544
Nebr:	Omaha	21,280	1,120	3,360	23,520	5,652	224	840	6,268
Nev:	Las Vegas[b]	6,195	[c]—	700	6,895	1,624	—	252	1,876
N.H:	Manchester	10,625	280	840	11,185	5,929	224	672	6,377
N.J:	Trenton	9,715	700	1,120	10,135	4,704	308	700	5,096
N. Mex:	Albuquerque	6,935	280	1,120	7,775	1,806	84	280	2,002
N.Y:	Buffalo	8,980	420	840	9,400	5,026	224	588	5,390
	New York	10,625	560	700	10,765	5,663	392	616	5,887
	Syracuse	9,540	560	700	9,680	4,732	280	588	5,040
N.C:	Charlotte	20,300	1,960	3,920	22,260	8,099	616	896	8,379
N.D:	Minot	18,210	1,680	5,320	21,850	8,610	336	1,568	9,842
Ohio:	Cincinnati	17,325	1,960	2,240	17,605	5,999	532	980	6,447
	Cleveland	10,940	1,260	1,120	10,800	4,921	280	672	5,313
Okla:	Oklahoma City	27,160	3,220	4,620	28,560	7,175	532	840	7,483
Ore:	Portland	33,950	3,780	5,880	36,050	5,733	672	1,344	6,405
Pa:	Philadelphia	10,555	1,120	1,960	11,395	5,446	420	840	5,866
	Pittsburgh	12,480	980	1,260	12,760	6,335	364	616	6,587
P.R:	San Juan[d]	27,335	1,680	2,800	28,455	3,990	224	532	4,298
R.I:	Providence	9,750	560	1,260	10,450	5,215	308	812	5,719
S.C:	Charleston	22,885	2,380	3,920	24,425	7,847	532	784	8,099
S.D:	Rapid City	21,875	280	2,800	24,395	6,363	112	756	7,007
Tenn:	Chattanooga	34,685	4,480	6,580	36,785	8,722	896	1,204	9,030
	Memphis	33,845	3,500	5,320	35,665	8,519	784	1,148	8,883
Tex:	Austin	12,705	840	1,400	13,265	2,898	224	224	2,898
	Dallas	31,465	2,660	3,920	32,725	6,398	560	784	6,622
Utah:	Salt Lake City	12,145	980	840	12,005	4,165	196	532	4,501
Vt:	Burlington	11,045	280	700	11,465	5,124	224	532	5,432
Va:	Norfolk	18,340	1,680	2,660	19,320	7,189	504	728	7,413
Wash:	Seattle	23,625	3,640	5,320	25,305	5,964	672	980	6,272
	Spokane	14,560	2,240	4,480	16,800	5,257	448	1,008	5,817
W. Va:	Charleston	23,135	2,660	5,040	25,515	7,896	560	1,120	8,456
Wis:	Milwaukee	9,015	140	560	9,435	3,689	196	616	4,109
Wyo:	Laramie	20,720	700	1,960	21,980	4,515	168	644	4,991

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual strontium-89 and strontium-90 intake per person from milk may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month Sr^{89} or Sr^{90} index × milk consumption factor = 12-month Sr^{89} or Sr^{90} intake

(pc day/liter) (liter/day/person) (pc/person)

[b] Station included in network in July 1962. The sum in column A is therefore for 11 months.
[c] A dash indicates no analysis.
[d] No sample was received for November 1962. The sums in columns A and D are therefore for 11 months.

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SECTION IV.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
March 1963

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service National Water Quality Network since its initiation in 1957. Beginning with the establishment of 50 sampling points, this network has expanded to 126 stations as of August 1, 1963, (figure 1), operated jointly with State, Federal and local agencies and industry. Surface waters of all major river basins of the United States are sampled and analyzed physically, chemically, biologically and radiologically. These data can be used for evaluating sources of radioactivity which may effect specific domestic, commercial, and recreational uses of surface water. Further, the Network provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the Network are published in an annual compilation (*1–6*).

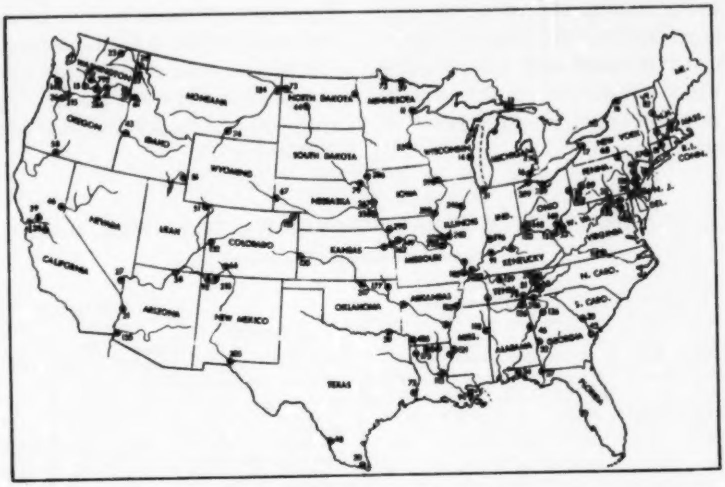
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
SOUTH DAKOTA
WYOMING
WISCONSIN
MICHIGAN
NEW YORK
MASS.
R.I.
CONN.
ME.
IOWA
NEBRASKA
N. J.
DEL.
NEVADA
UTAH
ILLINOIS
IND.
OHIO
W. VA.
COLORADO
KANSAS
MISSOURI
KENTUCKY
VIRGINIA
CALIFORNIA
N. CARO.
S. CARO.
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
MISS.
ALABAMA
GEORGIA
TEXAS
FLORIDA

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, MARCH 1963

One-liter grab samples are collected weekly by personnel of the participating agencies and shipped to the Public Health Service laboratory in Cincinnati for analysis. Determinations of gross alpha and gross beta radioactivity in the suspended and dissolved solids and of strontium-90 activity in the solids are carried out on frequency schedules based on need.

Gross beta activity in each weekly sample was determined until essentially background levels were reached in January 1960. Thereafter, gross beta determinations were made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established Network stations. (Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.) On September 1, 1961, weekly determinations of gross beta activity again were instituted to permit rapid evaluation of fallout effects from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once monthly except where variable or high values observed during the first year indicated the need for more frequent measurement.

Normally, samples are counted at the Network laboratory within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample that shows unusually high activity during the first analysis. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not corrected by extrapolation to the time of collection.

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter.

Since the fourth quarter of 1958, strontium-90 analyses have been made on three-month composites of aliquots from weekly samples. Until the fourth quarter of 1961, the method used for determining strontium-90 was that described in the aforementioned reference (*7*). Tributylphosphate was used to extract ingrown yttrium-90 from the purified, coprecipitated strontium-90. Since that time a modification of a procedure described by Harley has been used (*8*). The yttrium-90, together with an yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, re-dissolved, and re-precipitated as yttrium oxalate and the latter is washed and counted in a low-background, anticoincidence, end-window proportional counter.

Table 1 presents March 1963 results of alpha and beta analyses of U.S. raw surface waters. These data are preliminary; reanalysis of some samples may be made and additional analyses, not completed at the time of this report, may become available. For final data one should consult the Network's *Annual Compilation of Data* (*6*). The figures for gross alpha and gross beta radioactivity represent either determinations made on composite samples or means of weekly determinations where composites were not made. The quarterly strontium-90 results for the past year are presented in Table 2.

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, NWQN, MARCH 1963

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa.	51	18	69	1	1	2
Animas River: Cedar Hill, N. Mex.	160	50	210	28	9	37
Apalachicola River: Chattahoochee, Fla.	21	16	37	0	0	0
Arkansas River						
Coolidge, Kans.	38	97	135	4	46	50
Ponca City, Okla.	129	88	217	2	11	13
Bear River: Preston, Idaho	15	66	81	0	2	2
Big Horn River: Hardin, Mont.	40	34	74	6	2	8
Big Sioux River: Sioux Falls, S. Dak.	76	130	206	1	3	4
Chattahoochee River						
Atlanta, Ga.	115	21	136	3	5	8
Columbus, Ga.	35	17	52	1	0	1
Lanett, Ala.	30	16	46	3	0	3
Clearwater River: Lewiston, Idaho	11	50	61	0	0	0

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, NWQN, MARCH 1963—Continued

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Clinch River						
Clinton, Tenn.	26	25	51	<1	2	2
Kingston, Tenn.	150	132	282	2	1	3
Colorado River						
Loma, Colo.	78	54	132	8	6	14
Page, Ariz.	6	52	58	<1	11	11
Boulder City, Nev.	3	24	27	0	6	6
Parker Dam, Calif-Ariz.	1	20	21	0	9	9
Yuma, Ariz.	14	121	135	3	0	3
Columbia River						
Northport, Wash.	5	18	23	<1	<1	1
Wenatchee, Wash.	3	17	20	0	3	3
Pasco, Wash.	70	722	792	0	1	1
McNary Dam, Ore.	44	322	366	<1	2	2
Bonneville, Ore.	40	175	215	0	0	0
Clatskanie, Ore.	30	118	148	0	0	0
Cumberland River: Clarksville, Tenn.	100	39	139	6	0	6
Connecticut River						
Wilder, Vt.	1	81	82	1	1	2
Northfield, Mass.	14	24	38	0	0	0
Enfield Dam, Conn.	44	37	81	<1	0	<1
Cuyahoga River: Cleveland, Ohio	135	74	209	6	2	8
Delaware River						
Martins Creek, Pa.	39	21	60	0	0	0
Trenton, N.J.	27	50	77	0	0	0
Philadelphia, Pa.	64	39	103	1	0	1
Escambia River: Century, Fla.	14	20	34	2	1	3
Great Lakes						
Duluth, Minn.	1	10	11	0	0	0
Sault Ste. Marie, Mich.	2	10	12	0	0	0
Milwaukee, Wisc.	3	11	14	0	0	0
Gary, Ind.	5	16	21	0	0	0
Port Huron, Mich.	12	13	25	0	0	0
Detroit, Mich.	1	15	16	0	0	0
Buffalo, N.Y.	1	16	17	0	0	0
Green River: Dutch John, Utah	13	38	51	1	4	5
Hudson River: Poughkeepsie, N.Y.	29	28	57	0	0	0
Illinois River						
Peoria, Ill.	143	103	246	1	0	1
Grafton, Ill.	168	104	272	2	0	2
Kanawha River: Winfield Dam, W. Va.	20	33	53	0	5	5
Klamath River: Keno, Ore.	28	30	58	1	1	2
Little Miami River: Cincinnati, Ohio	363	85	448	12	0	12
Maumee River: Toledo, Ohio	218	141	359	2	1	3
Merrimack River: Lowell, Mass.	21	38	59	0	<1	<1
Mississippi River						
St. Paul, Minn.	15	38	53	1	2	3
Dubuque, Iowa	410	188	598	2	0	2
Burlington, Iowa	120	80	200	1	1	2
E. St. Louis, Ill.	211	69	280	3	2	5
Cape Girardeau, Mo.	150	35	185	10	0	10
W. Memphis, Ark.	82	20	102	6	2	8
Vicksburg, Miss.	121	39	160	6	<1	6
New Orleans, La.	69	25	94	6	0	6
Missouri River						
Williston, N. Dak.	22	51	73	2	4	6
Bismarck, N. Dak.	14	30	44	0	3	3
Yankton, S. Dak.	9	70	79	0	3	3
Omaha, Nebr.	303	64	367	7	34	41
St. Joseph, Mo.	245	53	298	43	3	46
Kansas City, Kans.	106	56	162	20	11	31
Missouri City, Mo.	191	58	249	18	4	22
St. Louis, Mo.	231	49	280	20	6	26
Monongahela River: Pittsburgh, Pa.	96	11	107	4	1	5
North Platte River: Henry, Nebr.	14	53	67	<1	28	28
Ohio River						
Addison, Ohio	90	50	140	4	<1	4
Huntington, W. Va.	126	27	153	2	0	2
Cincinnati, Ohio	123	30	153	8	0	8
Evansville, Ind.	76	15	91	4	0	4
Cairo, Ill.	267	36	303	21	0	21
Ouachita River: Bastrop, La.	52	56	108	1	1	2
Pend Oreille River: Albeni Falls Dam, Idaho	16	12	28	0	<1	<1
Platte River: Plattsmouth, Nebr.	[illegible]84	154	538	33	6	39
Potomac River						
Williamsport, Md.	16	17	33	0	0	0
Great Falls, Md.	40	33	73	0	0	0
Rainy River						
Baudette, Minn.	7	66	73	0	0	0
International Fls, Minn.	3	56	59	0	0	0
Red River, South						
Denison, Tex.	2	48	50	0	0	0
Index, Ark.	304	101	405	12	1	13
Bossier City, La.	131	44	175	3	0	3
Alexandria, La.	88	25	113	1	0	1
Rio Grande River						
Alamosa, Colo.	10	56	66	0	1	1
El Paso, Tex.	175	30	205	0	3	3
Laredo, Tex.	8	40	48	1	4	5
Brownsville, Tex.	5	15	20	0	1	1
Roanoke River: John H. Kerr Resr. & Dam, Va.	33	23	56	1	0	1
Sabine River: Ruliff, Tex.	37	36	73	1	0	1
Sacramento River: Green's Landing, above Courtland, Calif.	14	15	29	1	1	2
San Joaquin River: Vernalis, Calif.	12	26	38	1	3	4
San Juan River: Shiprock, N. Mex.	40	52	92	5	23	28
St. Lawrence River: Massena, N.Y.	1	15	16	0	0	0
Schuylkill River: Philadelphia, Pa.	144	90	234	1	0	1
Savannah River						
North Augusta, Ga.	18	12	30	0	0	0
Port Wentworth Ga	19	24	43	1	0	1
Shenandoah River: Berryville, Va.	23	103	126	0	7	[illegible]
Ship Creek: Anchorage, Alaska	7	26	33	0	<1	<1
Snake River						
Ice Harbor Dam, Wash.	10	22	32	0	1	1
Wawawai, Wash.	19	22	41	1	0	1
Payette, Idaho	9	34	43	0	0	0
South Platte River: Julesburg, Colo.	44	[illegible]	110	2	44	46
Spokane River: Post Falls, Idaho	8	14	22	<1	0	<1
Susquehanna River						
Syre, Pa.	45	23	68	1	0	1
Conowingo, Md.	23	15	38	0	0	0
Tennessee River						
Lenoir City, Tenn.	48	20	68	2	1	3
Chattanooga, Tenn.	238	48	286	12	1	13
Bridgeport, Ala.	85	41	126	4	0	4
Pickwick Landing, Tenn.	50	28	78	0	1	1
Tombigbee River: Columbus, Miss.	83	35	118	2	1	3
Truckee River: Farad, Calif.	4	42	46	1	0	1
Verdigris River: Nowata, Okla.	124	53	177	12	3	15
Wabash River: New Harmony, Ind.	191	105	296	2	1	3
Willamette River: Portland, Ore.	24	12	36	1	1	2
Yakima River: Richland, Wash.	5	10	15	0	1	1
Yellowstone River: Sidney, Mont.	80	44	124	13	2	15
Maximum	410	722	792	43	46	46
Minimum	1	10	11	0	0	0

TABLE 2.—QUARTERLY STATION AVERAGE CONCENTRATIONS OF STRONTIUM-90 IN RAW SURFACE WATERS, APRIL 1962–MARCH 1963

(Concentrations in pc/liter)

Station	Second quarter 1962	Third quarter 1962	Fourth quarter 1962	First quarter 1963
Allegheny River: Pittsburgh, Pa	1.2	2.1	1.8	[a]—
Animas River: Cedar Hill, N. Mex	1.0	0.4	0.9	—
Apalachicola River: Chattahoochie, Fla	0.9	0.4	0.1	—
Arkansas River				
Coolidge, Kans	3.9	2.6	1.0	—
Ponca City, Okla	3.0	4.8	2.2	—
Bear River: Preston, Idaho	—	[b]1.3	0.9	—
Big Horn River: Hardin, Mont	6.4	3.7	1.3	—
Big Sioux River: Sioux Falls, S. Dak	5.9	5.4	2.5	—
Chattahoochie River				3.6
Atlanta, Ga	0.8	0.7	1.0	—
Columbus, Ga	—	[c]0.8	1.1	—
Lanett, Ala	—	1.5	0.8	—
Chena Slough: Fairbanks, Alaska	[c]1.4	0.4	0.3	—
Clearwater River: Lewiston, Idaho	0.4	0.5	0.4	—
Clinch River				
Clinton, Tenn	—	1.3	1.0	
Kingston, Tenn	1.7	12.6	—	6.3
Colorado River				
Yuma, Ariz	1.0	1.2	0.9	—
Parker Dam, Ariz.-Calif	1.7	1.7	1.3	—
Boulder City, Nev	2.0	1.7	1.5	—
Page, Ariz	4.9	1.5	6.9	1.5
Loma, Colo	1.5	0.8	0.5	—
Columbia River				
Clatskanie, Ore	0.7	0.6	0.9	—
Bonneville Dam, Ore	1.6	0.4	1.2	1.4
McNary Dam, Ore	0.7	1.4	1.0	—
Wenatchee, Wash	0.8	1.2	1.6	2.3
Pasco, Wash	0.8	1.8	1.5	—
Northport, Wash	0.6	1.3	0.9	—
Connecticut River				
Northfield, Mass	1.0	1.3	1.0	—
Enfield Dam, Conn	1.0	1.4	1.0	—
Wilder, Vt	0.8	1.4	0.9	—
Cuyahoga River: Cleveland, Ohio	—	—	—	1.4
Delaware River				
Philadelphia, Pa	1.3	1.6	2.4	—
Trenton, N.J	1.6	1.5	0.9	—
Martins Creek, Pa	1.1	0.5	1.2	—
Escambia River: Century, Fla	1.1	1.0	—	—
Great Lakes				
Lake Superior: Duluth, Minn	0.5	0.7	0.7	—
St. Marys River: Sault Ste. Marie, Mich	0.6	0.9	0.8	—
Lake Michigan: Milwaukee, Wis	0.7	0.9	0.8	—
St. Clair River: Port Huron, Mich	1.3	1.0	0.8	—
Lake Erie: Buffalo, N.Y	1.1	1.3	1.7	—
Detroit River: Detroit, Mich	1.2	1.5	1.1	—
Lake Michigan: Gary, Ind	0.7	1.0	0.7	—
Green River: Dutch John, Utah	—	1.9	1.2	—
Hudson River: Poughkeepsie, N.Y	1.7	1.7	3.0	—
Illinois River				
Pere Marquette State Park, Grafton, Ill	2.4	1.4	1.8	—
Peoria, Ill	1.7	—	1.7	—
Kanawha River: Winfield Dam, W. Va	0.8	1.3	1.1	—
Klamath River: Keno, Ore	1.3	2.8	0.9	—
Little Miami River: Cincinnati, Ohio	2.9	0.9	1.6	—
Maumee River: Toledo, Ohio	—	—	—	3.6
Merrimac River: Lowell, Mass	—	—	0.9	—
Mississippi River				
New Orleans, La	2.3	2.1	1.9	—
Vicksburg, Miss	3.1	2.0	2.0	—
Delta, La	1.9	1.1	2.1	—
W. Memphis, Ark	2.7	2.4	2.0	—
Cape Girardeau, Mo	2.8	3.1	2.7	—
East St. Louis, Ill	2.2	2.7	1.8	—
Burlington, Iowa	2.0	2.1	2.1	—
Dubuque, Iowa	2.9	—	2.6	—
Lock & Dam, #3, St. Paul, Minn	3.9	4.7	3.4	—
Missouri River				
St. Louis, Mo	2.7	2.5	2.7	—
Missouri City	2.8	2.2	2.6	—
Kansas City, Kans	1.8	3.4	3.4	—
St. Joseph, Mo	3.0	5.7	1.9	—
Omaha, Nebr	4.2	3.8	2.5	—
Yankton, S. Dak	2.3	2.3	2.3	—
Bismarck, N. Dak	1.9	1.4	1.7	—
Williston, N. Dak	1.1	3.0	1.5	—
Monongahela River: Pittsburgh, Pa	0.9	1.8	1.5	—
North Platte River: Henry, Nebr	2.2	2.1	0.6	—
Ohio River				
Cairo, Ill	2.0	1.4	1.7	—
Evansville, Ind	1.4	1.3	1.6	—
Louisville, Ky	1.3	3.3	1.4	—
Cincinnati, Ohio	1.9	1.5	1.6	—
Huntington, W. Va	1.9	1.5	1.6	—
Addison, Ohio	—	1.3	2.1	—
E. Liverpool, Ohio	1.5	—	—	—
Ouachita River: Bastrop, La	1.6	1.0	1.6	—
Pend Oreille River: Albeni Falls Dam, Idaho	1.6	0.5	0.7	—
Platte River: Plattsmouth, Nebr	6.0	4.1	2.3	—
Potomac River				
Great Falls, Md	2.2	1.2	1.0	—
Williamsport, Md	0.9	1.2	1.6	—
Rainy River				
International Falls, Minn	2.4	1.4	1.8	—
Baudette, Minn	1.4	1.7	2.2	—
Red River (South)				
Alexandria, La	2.5	2.0	3.9	—
Bossier City, La	—	2.2	2.0	—
Index, Ark	6.1	—	3.3	—
Denison, Tex	2.2	1.1	5.0	—
Rio Grande River				
Brownsville, Tex	1.2	0.7	1.3	—
Laredo, Tex	2.0	1.8	1.8	—
El Paso, Tex	1.2	1.7	0.7	—
Alamosa, Colo	1.1	0.5	0.5	—
Roanoke River: John H. Kerr Resr. & Dam Va	2.5	1.8	1.1	—
Sabine River: Ruliff, Tex	1.7	1.0	1.4	—
Sacramento River: Greens Landing, Calif	0.9	0.8	0.9	—
St. Lawrence River: Massena, NY	1.2	0.3	1.2	—
San Joaquin River: Vernalis, Calif	—	0.7	1.0	—
San Juan River: Shiprock, N. Mex	1.0	1.0	1.7	—
Savannah River				
Port Wentworth, Ga	1.9	2.2	0.6	2.4
North Augusta, S.C	1.0	0.8	0.6	—
Schuylkill River: Philadelphia, Pa	1.5	1.8	1.3	—
Shenandoah River: Berryville, Va	0.9	0.4	0.8	—
Ship Creek: Anchorage, Alaska	[c]0.2	—	0.3	—
Snake River				
Ice Harbor Dam, Wash	0.9	1.1	1.6	—
Wawawai, Wash	0.6	0.9	0.7	—
Payette, Idaho	0.6	1.1	0.8	—
South Platte River: Julesburg, Colo	1.7	2.2	0.8	—
Spokane River: Post Falls, Idaho	0.7	0.9	0.8	—
Susquehanna River				
Conowingo, Md	1.0	2.1	1.2	—
Sayre, Pa	1.2	1.0	1.0	—
Tennessee River				
Pickwick Landing Dam, Tenn	1.7	1.1	1.4	—
Bridgeport, Ala	2.0	0.6	1.0	—
Chattanooga, Tenn	1.6	1.2	1.4	2.6
Lenoir City, Tenn	1.1	2.8	1.0	—
Tombigbee River: Columbus, Miss	1.4	1.6	0.6	—
Truckee River:				
California-Nevada Border: Farad, Calif	0.9	0.7	0.9	—
Verdigris River: Nowata, Okla	3.1	2.3	2.5	—
Wabash River: New Harmony, Ind	4.7	2.0	1.4	—
Willamette River: Portland, Wash	—	0.5	0.6	—
Yakima River: Richland, Wash	0.4	0.3	0.7	—
Yellowstone River: Sidney, Mont	3.0	1.5	2.0	—
Maximum	6.4	12.6	6.9	6.3
Minimum	0.2	0.3	0.3	0.4

[a] Dash indicates no data received.
[b] Aug.–Sept. composite.
[c] Six months composite.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the total beta activity in suspended-plus-dissolved-solids in raw water collected at that station. Network results for the years 1957–1962 have been summarized by Weaver *et al* (*9*).

REFERENCES

(*1*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data*, PHS Publication No. 663, 1958 Edition, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

(*2*) Ibid., 1959 Edition.

(*3*) Ibid., 1960 Edition.

(*4*) Ibid., 1961 Edition.

(*5*) Ibid., 1962 Edition (in press).

(*6*) Ibid., 1963 Edition (to be published).

(*7*) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).

(*8*) Harley, J. H.: Radiochemical Determination of Strontium-90, *Health and Safety Laboratory Manual of Standard Procedures*, August 1962 Revision, Radiochemistry and Environmental Studies Division, U.S. Atomic Energy Commission, New York Operations Office (1962).

(*9*) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957–1962, *Radiological Health Data*, 4:306–16, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (June 1963).

RADIOACTIVITY IN CALIFORNIA SURFACE WATER[1]

July–December 1962

Bureau of Radiological Health
State of California, Department of Public Welfare

Results obtained by the Bureau of Radiological Health in its monitoring of California surface water during the period July to December 1962 are summarized below. The importance of this facet of the Bureau's environmental surveillance program stems from the fact that most of California's domestic water supplies come from surface sources. Radioactivity in such water supplies consists of the natural radioactivity in surface streams and any radioactivity that may be added by the discharge of sewage or industrial waste effluents into streams. These water supplies may also contain radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Most of the supplies sampled represent raw surface waters although a few wells, along with some water supplies that use infiltration galleries, are also sampled (see figure 1).

It is necessary to monitor domestic water supplies on a continuous basis, since it is impossible to forecast levels of radioactivity in these supplies on the basis of radioactivity in rain, snow, or surface streams. The Bureau has established a monthly sampling schedule whereby 500-ml samples are collected and the total solids are analyzed for alpha and beta radioactivity. In addition, a three-liter sample is collected each month for a period of six months to make up a composite of approximately five gallons for strontium-90 analysis.

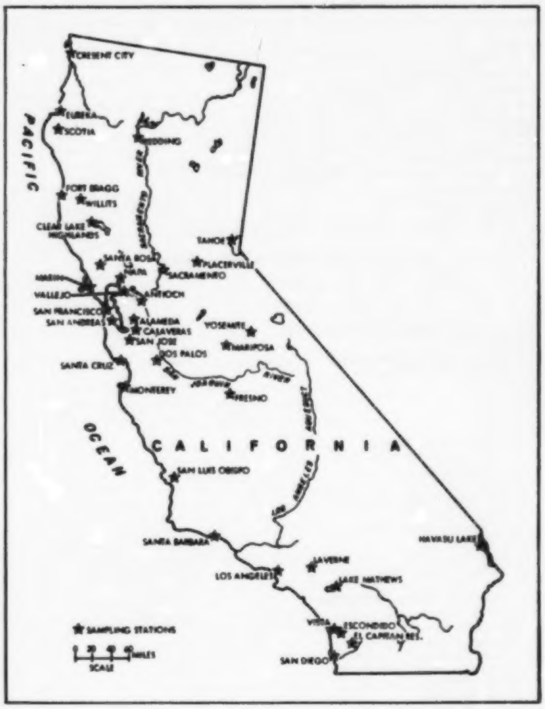
CRESCENT CITY
EUREKA
SCOTIA
REDDING
PACIFIC
FORT BRAGG
WILLITS
CLEAR LAKE HIGHLANDS
TAHOE
SANTA ROSA
PLACERVILLE
NAPA
SACRAMENTO
MARIN
VALLEJO
ANTIOCH
SAN FRANCISCO
SAN ANDREAS
ALAMEDA
CALAVERAS
YOSEMITE
SAN JOSE
MARIPOSA
DOS PALOS
SANTA CRUZ
MONTEREY
FRESNO
OCEAN
C A L I F O R N I A
SAN LUIS OBISPO
SANTA BARBARA
HAVASU LAKE
LAVERNE
LOS ANGELES
LAKE MATHEWS
VISTA
ESCONDIDO
EL CAPITAN RES.
SAN DIEGO
SAMPLING STATIONS
0 20 40 60 MILES
SCALE

FIGURE 1.—CALIFORNIA SURFACE WATER SAMPLING STATIONS

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[1] Abstracted from "Radiological Health News," Vol 2, No. 1 and 2, Jan. and April 1963, State of California, Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley 4, California.

Laboratory Methods

Radiological analysis of water samples are carried out in the Sanitation and Radiation Laboratory. All measurements of alpha and alpha-plus-beta activities are made with windowless, gas-flow, proportional counters. Five proportional counters, four of which are manual counters, are available to the Bureau. Two of the manual units have specially designed, shielded external detectors which reduce the alpha and beta backgrounds to 0.01 and 30 cpm, respectively. In the case of the two integrally constructed manual units the relatively high beta background has been reduced to 40 cpm by partial shielding of the scaler with lead bricks. The fifth counter is an automatic unit which has a beta backgound of about 15 cpm.

The Department's maximum capacity for alpha and beta radioactivity measurements during a normal work week is 500 thirty-minute counts. Counting methods used are in accordance with U.S. Public Health Service's recommended procedures (*1*).

Discussion

Table 3 shows the monthly average beta activity in the suspended-plus-the-dissolved solids in raw

TABLE 3.—GROSS BETA ACTIVITY IN CALIFORNIA SURFACE WATER, JULY-DECEMBER 1962

[Concentrations in pc/liter]

Sampling station	July	Aug.	Sept.	Oct.	Nov.	Dec.
Antioch	17.6	9.2[a]	14.4	31.0	[c]0	27.7
Chula Vista	10.7	[b]				
Clearlake Highlands	14.8			30.3	0	26.3
Crescent City	7.3	4.8	0	0	0	24.3
Dos Palos	0					
Escondido	34.1	10.1	0	0	33.6	0
Eureka	[c]6.6	1.9	15.4	45.3	0	24.7
Fort Bragg			12.4	74.9	61.8	0
Fresno: Lake Millerton	[c]20.9	[c]25.4	[c]23.7	[c]14.1	0	0
Los Angeles Department of Water and Power						
Big Tujunga				0		
Crystal Springs Wells				0		
Pollack Wells				0		
Marin Municipal Water District Nicasio Reservoir		9.1	0	0	0	0
Mariposa		17.2	0	0	49.3	0
Metropolitan Water Company of Southern California						
Lake Havasu		12.7	18.0	0	0	0
Lake Mathews	19.8	0	12.1	0	0	0
Monterey	0.6	10.7	1.3	25.1	0	45.1
Napa	8.8	8.6	5.0	0	0	0
North Marin County Water District	2.0	11.7	0	0	0	0
Oroville						
Wyandotte Irrigation District	9.9	32.0		30.7		68.8
California Water Service	1.9		4.7		0	
Placerville			24.5	0		
Redding	0	0	15.3	26.5	0	62.8
Sacramento	7.6	0		0	0	0
San Diego						
Alvarado Filter Plant	0	7.5	20.5			
El Capitan Reservoir		0				
First Aqueduct		22.3				
Hodges Reservoir		26.1				
Lower Otay Filter Plant		28.7		0		
Murray Reservoir	0			0		
San Dieguito Reservoir		0		0		
San Vicente		0				
Second Aqueduct						
Sutherland Reservoir		14.7				
Torrey Pines Reservoir		5.8				
San Francisco Water Department						
Alameda East	69.0	17.2	17.2	32.2	31.5	0
Brightside Weir	26.4	14.0		0	0	0
Calaveras Reservoir	3.6	3.5	1.5	0	0	0
Crystal Springs Raw Outlet	13.3	21.2	[c]0	0	0	0
Crystal Springs Line #1	[c]12.3	[c]4.0	[c]16.0	[c]11.0	[c]14.0	[c]0
Crystal Springs Line #2	0.1		4.4			
Hetch Hetchy	46.1	0.5	0	0	0	56.7
Lombard Reservoir	3.9	0	15.1	0	0	0
San Andreas Line #2	[c]7.6	[c]8.5	[c]6.2			[c]0
San Andreas Line #3				[c]0	[c]0	
University Mound	20.3	21.7	0	0	0	0
San Jose	34.5	4.2	1.1	0	0	0
San Luis Obispo	15.0					
Santa Barbara	2.7	4.0	14.2	0	50.5	0
Santa Cruz	[c]13.1	13.2	3.5	0	27.5	44.4
Santa Rosa		60.2	4.9	0	0	59.0
Scotia		0	0		0	0
Tahoe City	0	0	13.4	0		
Vallejo						
Fleming Hill	0	4.8	22.2	31.4	31.5	54.0
Swanzy Reservoir	8.9	10.2	0	0	0	28.2
Vista	32.1	25.1				0
Willits	27.5	26.3	7.1	0	0	40.0
Yosemite	17.2	18.3	0	45.0	0	30.8

[a] No significant activity.
[b] Blank space indicates no sample collected or analyzed.
[c] Average of more than one sample for the month.

surface water in California from July 1962 through December 1962. Following treatment, these waters are used for industrial and domestic purposes. Because alpha activity in water has, in general, been undetectable or very slight, alpha activity analyses are not presented.

REFERENCE

(*1*) Public Health Service: ***Radionuclide Analysis of Environmental Samples.*** Nov. 16, 1959, R59-6, Robert A. Taft Sanitary Engineering Center, Superintendent of Documents, U.S. Government Printing Office, Washington, 25-D.C. (1959).

Previous coverage in *Radiological Health Data:*

Period	*Issue*
1961–June 1962	*April 1963*

SECTION V.—OTHER DATA

In Vivo Measurement of Iodine—131 in Children's Thyroids

Francis I. Visalli[1]

Iodine-131 in the thyroids of a group of children was measured by *in vivo* counting at the Northeastern Radiological Health Laboratory from May to November 1962, a period covering a large part of the nuclear weapons testing series of both the United States and the U.S.S.R. During most of this period, little or no fallout radioiodine reached the greater Boston area so that no significant measurements could be made until about the middle of September. The iodine-131 measured was that present in the children as a result of normal environmental exposure during a fallout period. No radioiodine was administered to the children, nor did any child receive more radiation than he would have if he had not participated in the study. The iodine-131 contents of the thyroids of these children are presented in table 1.

Method of Measurement

Gamma scintillation spectroscopy was the method of measurement used. Measurements were made inside a small, shielded octagonal room with inside dimensions of approximately 43 inches across by 55 inches high. The walls of the room were 2⅛-inch thick iron plates lined on the inside with ¼ inch of lead plus $\frac{1}{16}$ inch of cadmium. A child being measured was placed in a semi-reclining position with his head tilted back to allow a 2.5-inch diameter x 1.5-inch thick, thallium-activated sodium iodide crystal to be placed over each lobe of the thyroid, as shown in figure 1. Because of the dimensions of the shielded room and the necessity of having having a child sit still for about 30 minutes, the study was limited to children from 7 to 14 years of age. Each child had his thyroid counted for 30 minutes twice a week. The measurement data were accumulated in a multichannel analyzer, using the region from 0.33 to 0.39 Mev as the iodine-131 peak.

The system was calibrated with iodine-131 in vials approximating the positions of the lobes of the thyroid in a lucite neck phantom. In order to simulate the scattering characteristics of the child, five 10-pound bags of sugar were used as a body phantom. In addition to these simulated calibrations, two adults who had been exposed to iodine-131 were measured with the Northeastern Radiological Health Laboratory equipment and were also measured in the whole body counter at New York University, which had previously been used for such measurements (*1*). The results of these cross calibrations were in agreement.

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[1] Miss Visalli is in charge of the iodine-131 thyroid studies at the Northeastern Radiological Health Laboratory, Division of Radiological Health, Public Health Service, 109 Holton Street, Winchester, Massachusetts.

TABLE 1.—IODINE-131 IN CHILDREN'S THYROIDS AND IN MILK, SEPTEMBER–NOVEMBER 1962

Date 1962	Iodine-131 in children's thyroids (pc/gland)								Milk[a] (Concentrations in pc/liter)
	Subject (age)								
	LG (7)	ES (7)	MP (10)	TT (10)	GRM (11)	BM (12)	DG (13)	SB (14)	
September 18					<30				10
19			<30	<30					
20	<30						<30	<30	
21		140							140
22									
23									
24						<30			
25					<30				210
26			<30	60					
27	<30						<30	<30	
28		100							170
29					<30				
30									
October 1		155				150	80		
2	40		150	115				125	130
3					170				
4		215				45	105		
5	90		135	65				160	100
6									
7					150				
8		195				135			
9	40		75					90	80
10					120				
11		225				75	60		70
12	<30		125	125				80	
13									
14					95				
15						95	<30		
16	<30		75	60				55	70
17					120				
18		110				105	45		
19			40	65					80
20									
21									
22		190				75			
23			65	115					70
24									
25		160				115			
26			50						90
27									
28									
29		145				65			
30									90
31									
November 1						180			
2									50
3									
4									
5		210				110			
6			70	120					50
7									[b]40
8		190				120			
9			85	120					40
10									
11									
12									40
13						100			
14									70
15									
16						60			
17									90
18									
19									50
20						90			

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[a] Boston station of the PHS Pasteurized Milk Network.

[b] Actual milk consumed after November 7, 1962—not identical with Boston network sample.

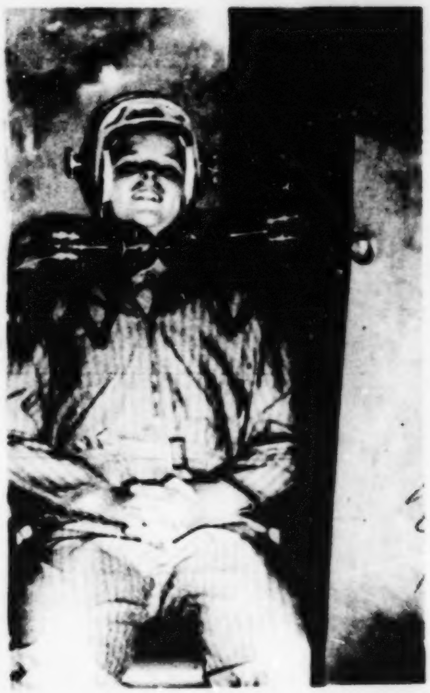

FIGURE 1.—SHIELDED ROOM WITH DOOR OPEN, SHOWING POSITION OF CRYSTALS AND CHILD DURING MEASUREMENT

Discussion of Results

With the equipment used, the estimated minimum detectable level of iodine–131 in the thyroid, defined as the level below which the random statistical error is greater than the measurement, is approximately 30 picocuries; therefore nondetectable results were reported as "less than 30 pc." The precision (reproducibility) of the thyroid measurements at relatively low levels is estimated to be ± about 30 pc; at higher levels the deviation is somewhat greater than this, but is probably not more than ± 50 pc at the highest level. These errors are at the 90 percent level of confidence (1.64 standard deviations). Accuracy of the measurements, because of the uncertainty as to the position of the thyroid in the neck, is not as good as this.

Since the reported measurements are limited to eight children, it is not possible to draw broad conclusions as to the range of the radioiodine content of childrens' thyroids in the entire population of the Boston area. It is significant, however, that no radioiodine was detectable in the children from May to mid-September of 1962, a period in which dietary radioiodine levels, as indicated by measurements in milk, were low. The rise in thyroid radioactivity followed very shortly the appearance of iodine–131 in Boston milk samples, and reached a peak value about ten to fourteen days after peak levels in milk were observed There was no apparent correlation between the levels of radioiodine in the children and the gross beta measurements in air (*2*), suggesting that diet is the chief source of thyroid iodine–131.

It was not possible to relate the concentration of iodine–131 in the childrens' thyroids directly to the levels in milk or to the intake from milk. The childrens' homes were served by different dairies and most of them also drank milk provided through several school milk programs. In addition, they consumed variable quantities of ice cream and other dairy products of unknown origin and also an unknown quantity of milk used in cooking.

An attempt to relate directly milk ingestion values to thyroid content was made during the last two weeks reported. A single source of milk from one of the larger Boston dairies was provided for all the children, and they were asked to report the amount used. Because the milk levels were rather low, and the children had previously established thyroid burdens, possible correlation could not be further considered. The iodine–131 content of this dairy's milk was found to be approximately the same as the composite Boston Milk Sample for the same period, so it may be taken as a first approximation that the levels in the composite of the Boston Milk Sample are an indication of the levels in the milk and other foods consumed by the children.

REFERENCES

(*1*) Eisenbud, Merrill, Yoshio Mochizuki, Abraham S. Goldin, and Gerard R. Laurer: Iodine–131 Dose From Soviet Nuclear Tests, *Science, 136:* 370–4 (May 4, 1962)

(*2*) Unpublished data, Northeastern Radiological Health Laboratory and Radiation Surveillance Center, Public Health Service.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports included data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. Summaries follow for Oak Ridge Area, and Paducah Plant.

The measured concentration of a radionuclide in air and water may be compared with the Maximum Permissible Concentration (MPC) of that nuclide as recommended by the National Committee on Radiation Protection and Measurement (NCRP). For the environment near an AEC installation, the applicable MPC's are one-tenth of the occupational MPC values for continuous exposures given in the National Bureau of Standards "Handbook 69" (*1*). The MPC values applicable to the reports that follow are given in table 1.

In the following reports, the use of nonspecific terms such as "total activity," "total alpha," and "gross beta" do not in themselves suggest any one MPC value. Often, when concentrations are low a laboratory will assign an MPC value that is more restrictive than necessary. This avoids the more costly isotopic tests necessary to justify a less restrictive value. References to table 1 will be made to designate the appropriate MPC's reported by the laboratories.

Table 1.—SELECTED ENVIRONMENTAL MPC VALUES PERTAINING TO AEC INSTALLATION REPORTS IN THIS SUBSECTION

Line No.	Radionuclide or mixture of unknown nuclides	Environmental MPC's	
		Water (pc/liter)	Air (pc/m^3)
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present^a	3,000	—
2	If Sr^{90}, Pb^{210}, Ra^{226}, Ra^{228} are not present^a	600	—
3	If Ra^{226}, Ra^{228} are not present^a	100	—
4	Mixture of unidentified nuclides	10	0.04
5	If α emitters and Ac^{227} are not present^a	—	1.0
6	If α emitters and Pb^{210}, Ac^{227}, Ra^{228}, Pu^{241} are not present^a	—	10
7	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, Bk^{249} are not present^a	—	100
8	Cerium-144	10,000	200
9	Cesium-137	20,000	500
10	Cobalt-60	30,000	300
11	Ruthenium-103-106	10,000	200
12	Strontium-90	100	10
13	Thorium-protactinium-234	20,000	1000
14	Uranium-natural	20,000	2
15	Zirconium-niobium-95	60,000	1000

[a] "Not present" implies the concentration of the nuclide is small compared with its appropriate MPC. According to AEC regulations, a group of nuclides may be considered not present if the ratio of each nuclide is equal to or less than 1/10 of its appropriate MPC and if the sum of these ratios for the group in question is equal to or less than 1/4.

REFERENCE

(*1*) National Committee on Radiation Protection: *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, National Bureau of Standards Handbook 69*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (June 5, 1959), price 35 cents.

OAK RIDGE AREA
Calendar Year 1962

Union Carbide Nuclear Company
Oak Ridge, Tennessee

This report presents 1962 data on the environmental levels of radioactivity for the Oak Ridge Area. As shown in figure 1, K-25, X-10 and Y-12 areas are located within the large AEC-controlled Oak Ridge Area. The Oak Ridge National Laboratory (ORNL) is located within the X-10 area and the Oak Ridge Gaseous Diffusion Plant (ORGDP) is located within the K-25 area.

Radioactive waste materials arising from the operation of atomic energy installations in Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ion exchange activity that enables it to fix radioactive materials. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches and pits located in the Conasauga shale formation. Low level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

Air Monitoring

Atmospheric contamination by long-lived fission products and fallout occurring in the general environment of East Tennessee are monitored by

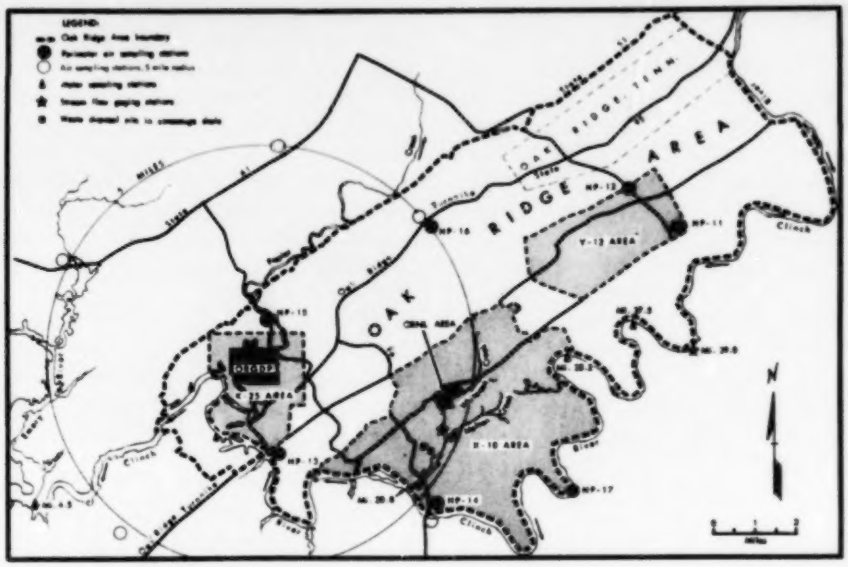

FIGURE 1.—OAK RIDGE AREA ENVIRONMENTAL SAMPLING LOCATIONS

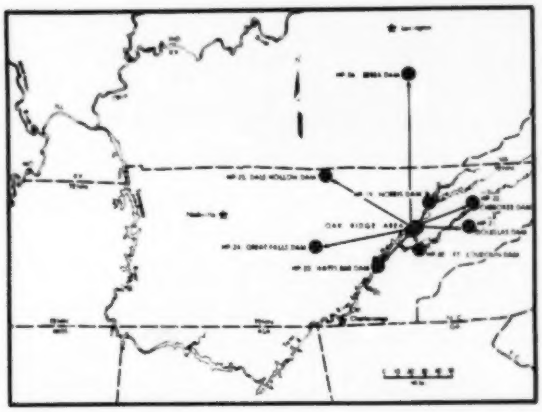

FIGURE 2.—REMOTE AIR MONITORING STATIONS, OAK RIDGE AREA

two systems of monitoring stations. One system consists of seven stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge Operations on the immediate environment. A second system consists of seven stations encircling the Oak Ridge Area at distances of from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur. Sampling is carried out by passing air continuously through a filter paper. Average concentrations are presented in table 2.

Atmospheric contamination by uranium is determined by gross alpha measurements of continuous air samples taken at five locations on a five-mile radius from the ORGDP (figure 1). The data are summarized in table 3.

TABLE 2.—LONG-LIVED GROSS BETA[1] CONCENTRATIONS IN AIR OAK RIDGE AREA, 1962

[Average concentrations in pc/m³]

Perimeter stations: (see fig. 1 & 2)	First half 1962	Second half 1962	Remote stations: (see fig. 1 & 2)	First half 1962	Second half 1962
HP-11	3.8	2.9	HP-19	5.2	3.5
HP-12	4.1	3.3	HP-20	4.7	3.8
HP-13	3.8	2.7	HP-21	5.2	3.6
HP-14	3.9	2.9	HP-22	4.5	3.6
HP-15	4.6	3.3	HP-23	5.0	3.9
HP-16	4.3	3.4	HP-24	5.1	4.0
HP-17	4.1	2.8	HP-25	4.5	3.2
Average	4.1	3.0	Average	4.9	3.6

[1] For MPC, see table 1, line 7.

Water Monitoring

Large volume, low level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River System by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and the Y-12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with the maximum permissible levels for populations in the neighborhood of a controlled area as recommended by the National Committee on Radiation Protection (NCRP). The concentration of radioactivity leaving White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

TABLE 3.—LONG-LIVED ALPHA[1] ACTIVITY IN AIR FIVE MILES FROM ORGDP

[Average concentrations in pc/m³]

Direction from plant	First half 1962	Second half 1962
North	0.17	0.28
East	0.16	0.36
South	0.17	0.30
West	0.16	0.46
Average	0.16	0.35

[1] Interpreted as uranium (natural).

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tennessee. Stream gauging operations are carried on continuously by the U.S. Geological Survey to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta emitters, for uranium, and for the transuranic alpha emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold-up time in the waste effluent system is such that no short-lived radionuclides are present. The averages are given in tables 4 and 5.

Gamma Measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge Area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above ground, and the results are shown in table 6 in terms of mr/hr.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*July 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*September 1962*

TABLE 4.—CONCENTRATIONS OF MAJOR RADIONUCLIDES IN THE CLINCH RIVER

[Average concentrations in pc/liter]

Radionuclide	First half 1962			Second half 1962		
	Location on Clinch River[a]			Location on Clinch River[a]		
	Mi. 41.5 (Upstream)	Mi. 20.8[b] (Outfall)	Mi. 4.5 (Downstream)	Mi. 41.5 (Upstream)	Mi. 20.8[b] (Outfall)	Mi. 4.5 (Downstream)
Sr^{90}	2.0	2.2	4.1	1.1	1.4	2.8
Ce^{144}	1.7	0.3	2.7	1.0	0.2	2.3
Cs^{137}	0.1	1.2	1.2	0.2	0.9	0.1
$Ru^{103-106}$	9	180	210	7	94	110
Co^{60}	[c]ND	2.4	4.1	ND	1.8	1.8
$Zr^{95} - Nb^{95}$	6.8	2.4	7.4	1.6	0.2	3.4
Gross beta	20	390	230	11	290	120

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River. See figure 1.

[b] The concentrations at mi. 20.8 are not measured directly but the values are calculated on the basis of levels of waste released and the dilution afforded by the river.

[c] ND—None detected.

TABLE 5.—URANIUM CONCENTRATIONS IN THE CLINCH RIVER, OAK RIDGE AREA

[Average concentrations in pc/liter]

Sampling location	First half 1962		Second half 1962	
	Number of samples	Uranium concentration	Number of samples	Uranium concentration
Upstream from ORGDP	27	0.2	25	1
Downstream from ORGDP	27	0.2	26	4

TABLE 6.—EXTERNAL GAMMA RADIATION LEVELS, OAK RIDGE AREA

[Average dose rates in mr/hr]

Location	First half 1962	Second half 1962
Solway Gate	0.030	0.036
Y-12 East Portal	0.021	0.030
Newcomb Road	0.027	0.028
Gallaher Gate	0.034	0.033
White Wing Gate	0.021	0.028
Average	0.027	0.031

PADUCAH PLANT
Calendar Year 1962

Union Carbide Nuclear Company
Paducah, Kentucky

The Paducah Plant is a Government-owned gaseous diffusion plant operated by Union Carbide Nuclear Company for the Atomic Energy Commission. The gaseous diffusion plant and the associated uranium hexafluoride manufacturing plant and uranium metal foundry process large quantities of relatively pure uranium compounds. The major sources of radiation from such materials are thorium-protactinium-234, and beta-emitting daughters of uranium-238, concentrated in the ash produced during the fluorination process. Since the element uranium can be a physiological hazard only if it enters the body, the chemical toxicity of the uranium materials processed at the Paducah Plant overshadows any radiation danger from this element.

Uranium is a rather expensive metal, and thus the incentive to recover as much as is economically feasible is great. The added desire to protect the population and to maintain a wholesome relationship with neighboring communities and individuals makes it essential that the air be exhausted through filters, and all effluent waters be discharged at extremely low concentrations of uranium.

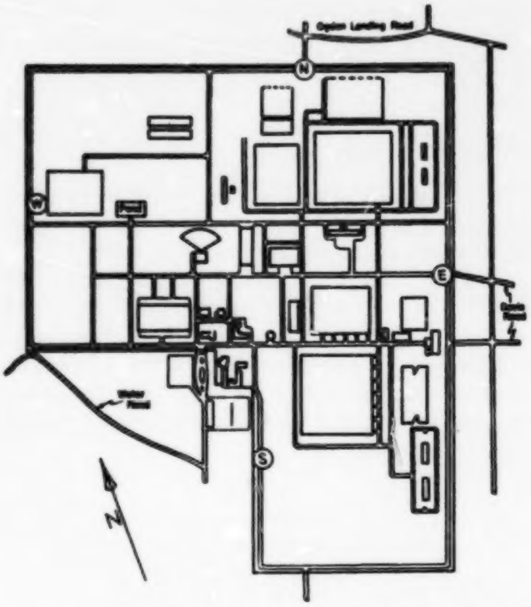
Ogden Landing Road
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FIGURE 3.—AIR SAMPLING POSITIONS, PADUCAH GASEOUS DIFFUSION PLANT

Since no recovery process or filtering system is 100 percent efficient, the environmental monitoring program used to evaluate the effectivness of such measures consists of a continuing system for sampling air in four stations around the plant perimeter

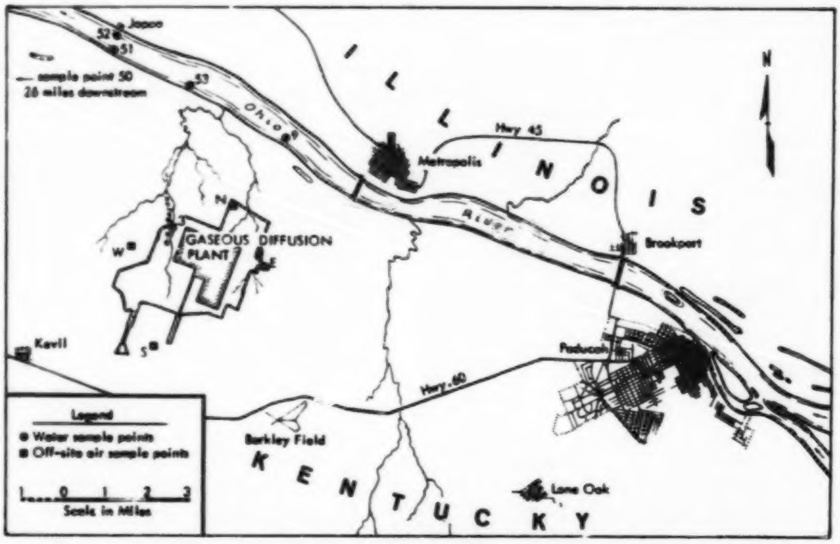
Joppa
52
51
sample point 50
26 miles downstream
53
Ohio
River
ILLINOIS
Hwy 45
Metropolis
N
Brookport
GASEOUS DIFFUSION PLANT
N
W
E
S
Kevil
Paducah
Hwy 60
Barkley Field
KENTUCKY
Lone Oak
Legend
● Water sample points
■ Off-site air sample points
1 0 1 2 3
Scale in Miles

FIGURE 4.—WATER SAMPLING LOCATIONS, PADUCAH GASEOUS DIFFUSION PLANT

fence, and four off-site stations; and for sampling water at one location in Big Bayou Creek, and four locations on the Ohio River as shown in figures 3 and 4.

Discussion of Data

Data summarizing the environmental levels of radioactivity in the vicinity of the Paducah plant for 1962 are presented in tables 7, 8, and 9.

During 1962, air samples were collected continously at each of the four air sampling stations at the plant perimeter fence and at four air sampling stations about one mile outside the plant perimeter fence. Samples are collected during a sampling period approximating a 168-hour week using a membrane filter.

TABLE 7.—RADIOACTIVITY IN AIR, ENVIRONMENT AROUND PADUCAH PLANT, 1962

[Concentrations in pc/m³]

Sampling location	Uranium alpha			Beta[1]		
	First half	Second half	Year	First half	Second half	Year
Plant perimeter						
N	0.13	0.13	0.13	8.3	12	10
E	0.10	0.10	0.10	11	6.0	8.3
S	0.07	0.07	0.07	5.5	5.1	5.1
W	0.06	0.06	0.06	6.0	6.0	6.0
One mile outside perimeter						
N	0.06	0.07	0.07	5.5	6.0	6.0
E	0.05	0.08	0.07	5.5	5.1	5.0
S	0.06	0.06	0.06	5.5	5.5	5.5
W	0.05	0.05	0.05	5.5	4.6	5.1

[1] Interpreted as thorium-protactinium-234.

The average uranium analysis of the 417 air samples collected during the year 1962 was 3.7% of the envirnomental MPC for uranium, and the mean beta count of 418 air samples collected during the year was 0.6% of the MPC for thorium-protactinium-234, the daughter products of uranium-238.

TABLE 8. RADIOACTIVITY IN WATER, ENVIRONMENT AROUND PADUCAH PLANT, 1962

[Concentrations in pc/liter]

Sampling location	Uranium			Beta[1]		
	First half	Second half	Year	First half	Second half	Year
Big Bayou Creek 3	10	14	12	200	200	200
Ohio River 9	1	<1	<1	100	100	100
Composite of 50, 51, 52, and 53	1	<1	<1	100	100	100

[1] Interpreted as thorium-protactinium-234.

The average uranium analysis for 52 water samples collected from the Big Bayou Creek during the year 1962 was about 0.06% of the MPC for uranium, and the beta average was 1% of the MPC for thorium-protactinium-134. The average beta analysis for 12 samples collected below the plant in the Ohio River for the year was 0.5% of the daughter products of uranium-238.

TABLE 9.—EXTERNAL GAMMA RADIATION LEVELS, PADUCAH PLANT, 1962

[mr/hr]

Sampling locations	First half	Second half	Year
Plant Perimeter			
N	0.02	0.02	0.02
E	0.03	0.02	0.03
S	0.02	0.02	0.02
W	0.02	0.02	0.02
One Mile outside perimeter			
N	0.02	0.02	0.02
E	0.02	0.03	0.02
S	0.02	0.02	0.02
W	0.02	0.02	0.02

External gamma radiation in the vicinity of the Paducah plant averaged 0.02 mr/hr for the year.

Period	*Issue*
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*July 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*August 1962*

Reported Nuclear Detonations

August 1963

Three nuclear detonations were announced by the Atomic Energy Commission for the month of August 1963. These were low yield tests conducted underground at the Nevada Test Site on the twelfth, fifteenth, and twenty-third of the month. (Low yield range has been announced as less than 20 kilotons yield.) *Radiological Health Data* has assigned the following reference numbers according to test dates: 108, 109 and 110.